MEDICAL USES OF SOAP

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A Symposium

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Preface

This collection of articles forms a symposium on the medical uses of soap. Each of the authors has previously contributed to the medical writings in this field. Occasional duplications have been permitted in order to bring out individual points of view relating to some debatable questions, such as the effects of free alkali, the comparative values of soap and soapless detergents, and similar subjects. This series of articles answers many of the questions as to the effects of soap on the normal skin and hair, on the abnormal skin, the effects of soaps used in shaving and shampooing, and irritation produced by soap under various conditions.

The continuous improvement of soaps and soap products is reflected in the new methods of manufacture described in those chapters which deal with the chemistry of soap and related problems.

M. F.

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G. THOMAS HALBERSTADT, B.S.CH.E.

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1

Soap Technology

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I. THE CHEMISTRY OF SOAP

DEFINITION

The meaning of the term *soap* may vary considerably with the particular viewpoint involved. If only the chemical nature of the material is considered, soap is any salt of those fatty acids that contain 8 or more carbon atoms. Some of these salts are soluble in water whereas others are not. Because of the importance of physical properties, it is usual to limit the definition to those fatty acid salts which are water-soluble, since they are the ones which exhibit such "soap-like" properties as sudsing, detergency, and surface tension lowering. Because of other technical considerations, the definition is sometimes further limited to that particular "phase" or form of soap which is normally produced in the soap kettle. This phase is a mass of practically constant composition made up of about 70 per cent soap, 30 per cent water, and a fraction of one per cent of salt. It is the result of a natural equilibrium and is variously known as *neat soap, genuine soap,* or *pure soap.*

The layman, in his concept of soap, usually includes the great variety of commercial soap products, some of which contain certain amounts of added materials that are not soap at all. He includes perhaps even various types of detergents which, chemically, are completely unrelated to soap.

For the purposes of this discussion, the term *soap,* unless qualified, will be understood to mean *any soluble salt of those fatty acids which contain 8 or more carbon atoms.* The comments, as well as the physical and chemical properties, presented in Part I of this chapter are intended to refer to the chemical compound soap and not to commercial products on the market unless so stated.

Chemically, soap may be represented as:

$$R—COOM$$

in which R = A straight chain hydrocarbon radical, saturated or unsaturated, normally with 7 to 21 carbon atoms.
—COO = Residue of a carboxyl group, characteristic of organic (carboxylic) acids.
M = A base-forming material, either inorganic or organic, of such a nature that R—COOM is soluble in water; sodium, potassium, and ammonia are typical of the inorganic materials; $HOCH_2CH_2NH_2$ (monoethanolamine) and $(HOCH_2CH_2)_3N$ (triethanolamine) are typical of the organic materials.

All soaps have this general formula; they may differ in the hydrocarbon chain (R), or in the base (M), or in both. Four typical examples are:

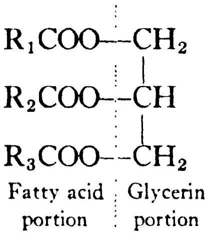
R_1COOM_1 $CH_3(CH_2)_{16}COONa$
Sodium stearate (R_1 is saturated)
R_2COOM_1 $CH_3(CH_2)_7CH = CH(CH_2)_7COONa$
Sodium oleate (R_2 is unsaturated)
R_2COOM_2 $CH_3(CH_2)_7CH = CH(CH_2)_7COOK$
Potassium oleate (R_2 is unsaturated)
R_3COOM_3 $CH_3(CH_2)_{14}COONH(CH_3CH_2OH)_3$
Triethanolamine palmitate (R_3 is saturated)

RAW MATERIALS USED IN SOAP MANUFACTURE

The raw materials of which soap is manufactured are natural fats of animal or vegetable origin, and water-soluble bases.

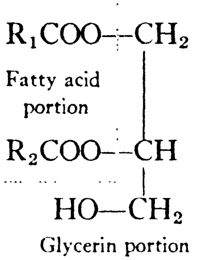
Chemically, fats are esters of fatty acids and glycerin. These esters, as obtained from nature, are either triglycerides or mixtures of triglycerides with small quantities of monoglycerides or diglycerides. (Their structural formulas are shown below.) Fatty acids and small amounts of other materials are frequently found associated with the fats.

Triglyceride



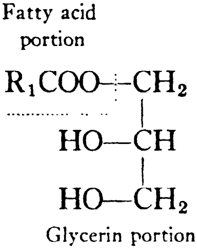
$$\begin{array}{r@{}l} R_1COO- & CH_2 \\ & | \\ R_2COO- & CH \\ & | \\ R_3COO- & CH_2 \end{array}$$

Diglyceride



$$\begin{array}{r@{}l} R_1COO- & CH_2 \\ & | \\ R_2COO- & CH \\ & | \\ HO- & CH_2 \end{array}$$

Monoglyceride



$$\begin{array}{r@{}l} R_1COO- & CH_2 \\ & | \\ HO- & CH \\ & | \\ HO- & CH_2 \end{array}$$

In these formulas, R_1, R_2, and R_3 may be the same or different straight chain hydrocarbon radicals, saturated or unsaturated, normally with 7 to 21 carbon atoms.

Many different types of fatty acids are known, and, since these may be arranged in different order in the triglyceride molecule, the number of possible fats is large. Actually a great variety of glycerides occurs in nature. Some are solids or semi-solids and others are liquids; these latter are called *oils* or *fatty oils.* Some of the more important fats are listed in Table I (see p. 4).

Any of the materials listed can be used to make soaps, but some are not regularly used in this manner, because normally they have greater value as foods. In this group fall butter, lard, certain vegetable oils (after special processing to salad oils, vegetable oil shortening, or margarin), and some of the fish liver oils (as a source of vitamins A and D).

TABLE 1

Animal Fats and Oils

Butter, from milk
Lard, from pigs
Marine oils, from fish, whales, and seals
Mutton tallow, from sheep
Tallow, from cattle

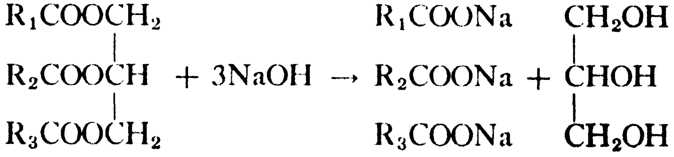
Vegetable Oils

Babassu nut
Coconut
Corn
Cottonseed
Linseed
Olive
Palm
Palm kernel
Peanut
Rapeseed
Sesame
Soybean
Sunflower
Tung

The water-soluble bases are either inorganic, such as sodium hydroxide and potassium hydroxide, or organic, such as triethanolamine. In the earliest history of soap-making, potassium hydroxide (from wood ashes) was used almost exclusively as the base because of its ready availability. The development of improved methods for the manufacture of sodium hydroxide led to its general use, since harder soaps can be made with this base. Potassium hydroxide is still rather widely used, either exclusively, as in liquid soaps for dispensers, or in conjunction with sodium hydroxide, as in certain bar, flake, and granulated products.

CHEMISTRY OF SOAP-MAKING

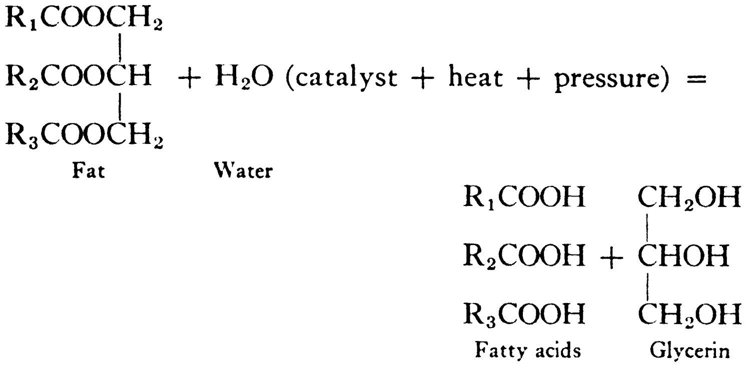
The molecule of fat can be split or hydrolyzed by water to give fatty acids and glycerin. This hydrolysis can be accelerated in many ways; it is hastened by certain catalysts and by heat. In the gastro-intestinal tract, the reaction is speeded by the fat-splitting enzymes or lipases; in the soap kettle, the reaction is speeded by caustic soda and steam. In each case, fatty acids and glycerin result. In the soap kettle, however, the fatty acids do not remain as such, but combine immediately with the caustic soda present to form soaps. Kettle soap-making is illustrated by the following equation:



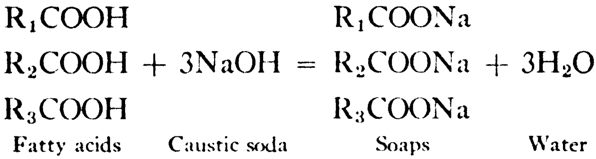
$$\begin{array}{ccccccc}
R_1COOCH_2 & & & & R_1COONa & & CH_2OH \\
| & & & & & & | \\
R_2COOCH & + & 3NaOH & \rightarrow & R_2COONa & + & CHOH \\
| & & & & & & | \\
R_3COOCH_2 & & & & R_3COONa & & CH_2OH \\
\text{Fat} & & \text{Caustic soda} & & \text{Soap} & & \text{Glycerin}
\end{array}$$

where R_1, R_2, and R_3 are as discussed above.

The most modern soap-making process does not produce soap by the kettle method of direct saponification, but by a two-stage method in which the fat is first split in an autoclave by hydrolyzing with steam in the presence of a catalyst at high temperature (approx. 450° F.) and pressure (approx. 600 lbs.). The fatty acids after purification, usually by distillation, are saponified with caustic soda to form soap. The chemical equations are as follows:

1.


$$\begin{array}{l} R_1COOCH_2 \\ \quad\quad\ \ | \\ R_2COOCH \\ \quad\quad\ \ | \\ R_3COOCH_2 \\ \text{Fat} \end{array} + \underset{\text{Water}}{H_2O} \text{ (catalyst + heat + pressure)} = \underset{\text{Fatty acids}}{\begin{array}{l} R_1COOH \\ R_2COOH \\ R_3COOH \end{array}} + \underset{\text{Glycerin}}{\begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}}$$

2.


$$\underset{\text{Fatty acids}}{\begin{array}{l} R_1COOH \\ R_2COOH \\ R_3COOH \end{array}} + \underset{\text{Caustic soda}}{3NaOH} = \underset{\text{Soaps}}{\begin{array}{l} R_1COONa \\ R_2COONa \\ R_3COONa \end{array}} + \underset{\text{Water}}{3H_2O}$$

Instead of hydrolyzing in an autoclave, the same reaction may be carried out by boiling at atmospheric pressure in the presence of a strong acid (1 to 5 per cent sulfuric acid) with a catalyst such as the well-known Twitchell Reagent (stearonaphthalenesulfonic acid). The fatty acids formed are distilled, in order to remove color and other extraneous matter, and are then neutralized with the desired base.

PHYSICAL AND CHEMICAL PROPERTIES OF SOAP

Soap when dissolved in water lowers the surface tension, forms colloidal solutions and gels, causes the water to wet surfaces more rapidly, sudses or lathers, gives the solution a "soapy" or slippery feeling, and has the ability to emulsify and disperse oils and dirt in the solution and thus is able to cleanse. Although these characteristics vary in degree somewhat from one type of soap to another, depending on the raw materials used, they are the important physical characteristics of the compound, soap. Other physical properties, notably the rate of solution, nature of gels formed in concentrated solutions, and the hardness of the soap in bar form vary over a wide range, depending on the raw materials used.

Soap in solid form (not solutions) is capable of existing in a variety of crystalline forms which differ considerably in solution rate, hardness, lathering power, and other properties; the way in which the solid soap is cooled and processed in manufacturing controls the crystalline modification of the soap produced. Consequently, chemical analyses of soaps do not give complete information concerning their nature, for soaps of identical chemical composition may behave quite differently.

An important chemical reaction of the soap molecule is the one which occurs when soap is put into hard water,* that is, into water containing calcium, magnesium, and other soluble soap-consuming salts, usually in the form of the chlorides, sulfates, or bicarbonates. The soap reacts with these salts to form *lime soap*, a curdy, sticky, insoluble compound recognized by all as soap scum or the so-called "ring around the tub" deposit. The chemical reaction is as follows, taking sodium soap and calcium chloride as examples:

$$\underset{\substack{\text{Soluble}\\ \text{soap}}}{2RCOONa} + \underset{\substack{\text{Water}\\ \text{hardness}}}{CaCl_2} \rightarrow \underset{\substack{\text{Insoluble}\\ \text{lime soap}}}{(RCOO)_2Ca} + \underset{\substack{\text{Sodium}\\ \text{chloride}}}{2NaCl}$$

The reaction described occurs almost every time soap is put into water because practically all water contains some hardness. The amount of lime soap formed is, however, small when the water is relatively soft (New York and New England), but is considerable when the water is hard (many other sections of the United States). The body secretions also contain dissolved calcium and magnesium salts, so that some lime soap is always formed on the skin surface during washing; this effect is noticeable particularly when sweating is profuse. Even in hard water, if sufficient soap is present to form a suds, the lime soap precipitate is held in suspension and does not cause any difficulty. During rinsing, however, more hard water is added, precipitating all of the soap as lime soap and leaving no active soap in solution to disperse the lime soap. On standing, particularly if the temperature of the water drops, the lime soap gradually separates from solution. It then collects on the surface of the water or becomes deposited on any material with which it comes in contact—on the skin, on fabrics, or on the tub as the familiar "bath tub ring."

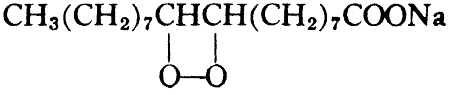
---

* Water hardness is determined most simply by titration with a standard soap solution. For greater accuracy, chemical analysis is required. Results are calculated to equivalents of calcium carbonate and are expressed either as *parts per million* or as *grains per U. S. gallon.* One grain of hardness per gallon is equivalent to 0.065 gram or 0.0023 ounce of calcium carbonate per gallon, or 17.1 parts per million.

Another important chemical reaction of the soap molecule is an oxidation reaction involving the breakdown of the molecule at the point of unsaturation in the carbon chain and causing the soap to become rancid. In the presence of air and moisture (particularly if the temperature is raised), the soap molecule becomes oxidized, probably as indicated in the following equation:

$$CH_2(CH_2)_7CH = CH(CH_2)_7COONa + H_2O + O_2 =$$

Sodium oleate



$$CH_3(CH_2)_7\underset{\displaystyle O\!-\!\!-}{\underset{|}{C}}H\underset{\displaystyle O}{\underset{|}{C}}H(CH_2)_7COONa$$

The product so formed is unstable and on further oxidation may yield any of the following degradation products, and perhaps others:

$$CH_3(CH_2)_7CHO$$
$$CH_3(CH_2)_7COOH$$
$$CHO(CH_2)_7COONa$$
$$COOH(CH_2)_7COONa$$

The aldehydes and the lower fatty acids formed have an unpleasant odor and are irritating to the skin. The oxidation reaction which produces these materials is usually accompanied by discoloration of the soap. The reactions producing the two types of changes, however, are not necessarily identical.

When dissolved in water, soaps are ionized and partially hydrolyzed. The ionization reaction, in simple form, is as follows:

$$\text{RCOONa (in } H_2O) \rightleftarrows \text{RCOO}^- + \text{Na}^+$$

With increasing concentration, aggregation of the anions (RCOO^-) together with some neutral soap (RCOONa) takes place to form large, highly charged colloidal particles known as *ionic micelles.* These micelles have a considerable influence on the physical properties of soaps in solution.

The principal product of the hydrolysis of soaps is a type of compound known as *acid soap;* the reaction may be most simply represented as follows:

$$2\text{RCOONa} + H_2O \rightleftarrows \underset{\text{Acid soap}}{(\text{RCOO})_2\text{NaH}} + \text{Na}^+ + \text{OH}^-$$

In this equilibrium reaction, minute amounts of sodium hydroxide are formed, with the result that all aqueous soap solutions are slightly alkaline. This alkalinity exists even though the soap is very carefully prepared from exactly equivalent amounts of base and fatty acid.

Except in the presence of water, however, the soap molecule itself is not alkaline. This can be demonstrated by dissolving pure soap in a non-ionizing medium such as alcohol; under this condition, indicators show the solution to be approximately neutral. If an excess of either free alkali or free fatty acid is present, the alcoholic solution will not be neutral, and the extent of its deviation from neutrality may be determined by titration.

Soaps designed for certain purposes have alkaline *builders* (see pp. 20 and 32) added to them during the manufacturing process; these products are known as *built* soaps. The builders are, for the most part, insoluble in alcohol and may be identified by proper test on the residue from an alcoholic solution of the soap. The presence of builders has a variable effect on the pH of aqueous soap solutions, some causing a definite increase in pH while others have little or no effect. All these substances, however, increase the amount of *available alkali* in the soap.

The term *neutral soap* refers to those commercial soaps which do not contain builders or an excess of either free alkali or free fatty acid.

Another property of soap, its sanitation value, while physicochemical in nature, is also of physiological importance. *When used for skin cleansing, soap wets, emulsifies, and dissolves the oil and dirt on the surface of the skin. A certain portion of the neutral skin oil is emulsified along with any oily deposit from external sources, and the soap solution enters the deeper layers of the skin to some extent. During subsequent rinsing, oil, dirt, dead skin, and germs are flushed away. It is primarily in this way that cleansing with soap reduces danger of infection; additional protection results from the inherent bacteriostatic and, in many cases, germicidal action of soap toward pathogens.*

INFLUENCE OF RAW MATERIALS ON PHYSICAL AND CHEMICAL PROPERTIES OF SOAPS

Effect of Fats. The fats used have considerable influence on the physical and chemical properties of the soap. This is evident from the fact that a large portion of the soap molecule is derived unchanged from the fat; actually, over 90 per cent of the average soap molecule is derived from the fat, with less than 10 per cent coming from the base. An examination of the properties of natural oils and fats gives considerable insight, therefore, into the kind of soaps that can be made. Some fats are comparatively hard, waxy solids; these fats, such as mutton tallow, are of relatively high molecular weight and contain a rather high proportion of saturated fatty acids. Softer fats either are of lower average molecular weight or contain a higher proportion of unsaturated fatty acids. Butter, for example, while containing a high proportion of saturated fatty acids, is of moderately low molecular weight and hence is softer than mutton tallow; lard, while of high average molecular weight, contains a considerable proportion of unsaturated fatty acids and hence is also softer than mutton tallow and is of about the same consistency as butter. Similarly coconut oil, while containing a high proportion of saturated fatty acids, is of low average molecular weight and hence is a liquid at ordinary temperatures; olive oil, while of high average molecular weight, contains a high proportion of unsaturated fatty acids and hence is also a liquid at ordinary temperatures.

The rate of solution of soaps, particularly in cool or lukewarm water, the tendency to form gels in concentrated solution, and the firmness of bars formed are influenced considerably by the fats used. In general, the speed of solution increases and the tendency to form gels in concentrated solution decreases with decreasing molecular weight and with increasing degree of unsaturation. Bars formed from soaps made in the main from saturated fats are hard; this is true even when the average molecular weight of the fatty acids is quite low. On the other hand, bars formed from soaps made from highly unsaturated fats (such as olive oil) tend to be soft and must be specially dried to be satisfactory for use.

The nature of the fats used affects the kind of scum formed when soap is dissolved in hard water. Soap made from coconut oil and similar fats (of low molecular weight) react with the calcium and magnesium salts to form insoluble soap which disperses better than do the calcium and magnesium soaps of tallow and similar fats (where the fatty acids have a higher average molecular weight); the latter tend to form larger and more persistent lime soap curds.

The possibility of oxidation at the double bond or point of unsaturation and thus the development of rancidity depends largely on the nature of the fats used. Coconut oil soap (the fatty acids are almost all saturated) has practically no double bonds and hence is resistant to oxidation. Olive oil soap, in which 90 per cent of the constituent fatty acid molecules are unsaturated, is considerably less resistant to oxidation, and hence is much more likely to become rancid. When a large proportion of the fatty acid molecules contains two or more double bonds (as in cottonseed oil), the tendency toward rancidity is further increased.

The pH of soap solutions depends also in great measure on the nature of the fats used. For instance, sodium soaps made from coconut and similar oils give solutions of relatively low pH (under normal conditions between 9 and 10), while those made from tallow and similar fats give solutions of higher pH (as high as 10.8). In this connection, it is interesting to note that soaps made from tallow are milder to the skin than are those made from fats such as coconut oil, of lower molecular weight. *In general, pH and mildness both increase with increasing molecular weight; thus it is obvious that low pH is not necessarily an indication of mildness as is sometimes thought.*

The quality of the fats used affects the color of the soaps produced. Pure, carefully refined fats and oils form white soaps; poor quality fats contain extraneous colored materials which lead to the production of colored soaps. Pure olive oil, for example, can be converted into a nearly white soap. Soap made from the poorer grades of olive oil may have a green color.

Effect of Base. The base used has a marked effect on the physical properties of the soap. In general, soaps made from sodium are slowest to dissolve and are relatively firm; soaps of potash, ammonia, and some of the organic bases such as triethanolamine dissolve far more rapidly and tend to be soft and pasty. When certain bases (e.g., calcium and magnesium hydroxide) are used, the "soaps" formed are insoluble in water and are recognized as soaps only by the chemist. (See definition of soap at beginning of this chapter.)

Solutions of soaps made from strong bases (sodium and potassium hydroxide) have relatively high pH values (9.0-10.8, depending on the fats used), while solutions of soaps made from weaker bases (triethanolamine, etc.) have relatively lower pH values (8.0-9.5).

Relation of Raw Materials to Types of Soap. The influence of the raw materials used, on the characteristics of the soap produced, is brought out rather clearly by the following comparison of different types of soaps with the raw materials used to produce them.

1. Toilet bars must be firm and fairly soluble but not so soluble that they waste away on the washstand. They are made largely from natural solid fats (such as tallow and palm oil) and from unsaturated liquid oils (soybean oil, marine oils) which have been hardened by a hydrogenation process. Some coconut oil is added to improve the lathering qualities and firmness of the bar. The fatty acids are thus of rather high average molecular weight and are, for the most part, saturated. The base used is sodium hydroxide.

2. Bars for use with sea water must be just as firm as other toilet bars but must lather readily in the hard sea water. They are made from coconut oil; thus the fatty acids are saturated and are of relatively low molecular weight. The base used is sodium hydroxide.

3. Liquid soaps for dispenser use must not gel at room temperature in the concentrations used (10 to 15 per cent); they are made largely from coconut oil and potassium hydroxide. Vegetable oils such as cottonseed oil, corn oil, etc. (rather highly unsaturated), may be used, but the products do not suds satisfactorily and have too great a tendency to gel.

✓ 4. Sapo mollis, U.S.P. (soft soap), is required to be an easily dissolved paste made from oils other than coconut or palm kernel. It is made from unsaturated vegetable oils and potassium hydroxide.

✓ 5. Sapo durus, U.S.P. (hard soap), must be firm and highly soluble (with the use of coconut or palm kernel oil virtually precluded by the specifications). It is made from vegetable oils, such as olive oil, and sodium hydroxide; the fatty acids are of long chain and are largely unsaturated.

6. "Castile" soap originally referred to the olive oil soap manufactured in the Spanish province of Castile. The inferior lathering properties of olive oil soaps led many manufacturers to improve these qualities by the incorporation of coconut oil soap, while retaining the name "castile." The term has now entirely lost its original significance, and may be applied to any toilet soap without reference to the fats from which it is made.

Tests Used to Identify Fats and Their Soaps

Since the chemical nature of the fatty acids determines largely the characteristics of the fats and soaps in which they are present, tests for characterizing these fatty acids are of particular importance. Three tests—titer, saponification value, and iodine value—give a fairly complete picture of the kind of fatty acids present.

The titer is the solidifying point, measured under specified conditions, of the constituent fatty acids of the soap or fat; it reflects the chemical nature of the fatty acids to a large degree. Fats consisting primarily of low molecular weight fatty acids or unsaturated fatty acids have low titers (under 25° C.); increased molecular weight or increased saturation raises the titer (42° C. for tallow).

The saponification value is a measure of the average molecular weight of the fatty acids being tested; it is defined as the number of milligrams of potassium hydroxide necessary to saponify one gram of fat or fatty acids. Fats consisting primarily of high molecular weight fatty acids have low saponification values (185 to 210); those consisting largely of low molecular weight fatty acids have high saponification values (235 to 275).

The iodine value is a measure of the average degree of unsaturation of the fatty acids. Numerically, it is the number of centigrams of iodine absorbed under prescribed conditions by one gram of fat or fatty acids; i.e., it is the percentage of iodine absorbed by the fatty material under the test conditions. Coconut oil, consisting primarily of saturated fatty acids, has an iodine value of about 10, while olive oil, consisting largely of unsaturated fatty acids, has an iodine value of 80 to 90.

II. THE MANUFACTURE OF SOAP

This section is devoted primarily to commercial soap products, in contrast with Part I which was limited to the chemical compound *soap*.

As described previously, the chemical reaction involved in soap-making is simply the splitting of fats and the neutralization of the resulting fatty acids with alkali. Three distinct methods for the industrial application of this reaction are worthy of some attention.

Cold Process

In the simplest procedure for soap manufacture, the only external heat needed is that required to melt the fats. A temperature of about 95° F. is sufficient, hence the term "cold" process. The calculated amounts of fat and alkali are mixed together, along with any perfume or other material to be added. The mixture is discharged into "cooling frames," large metal boxes with removable sides, where saponification continues with the evolution of considerable heat; completion of the reaction requires several hours. The soap is allowed to stand in the frames for several days in order to cool and solidify. The sides of the frames are then removed and the soap cut into bars, stamped, and wrapped.

The principal advantages of this method are its simplicity, low equipment cost, low heating cost, and relative rapidity. This process is particularly applicable to the manufacture of 100 per cent coconut oil soaps, for it is difficult to make these by the popular *kettle process.* However, all the glycerin, which is produced in the saponification reaction, is retained in the finished product, as are any impurities which may have been present in the fat stock. Only a relatively small amount of soap is now being made by cold process.

KETTLE PROCESS

Soap was originally made by boiling fat and alkali (wood ashes) together in a large kettle. Since that time, there have been many technical improvements in the operation. *By far the greatest volume of soap is still being produced by the kettle process.*

The modern soap kettle is a massive vessel equipped for the controlled delivery of fats, lye, salt, water, and steam, and for the separate removal of soap and by-products (including impurities). (See Figure 1.)

Fat and a relatively weak solution of sodium hydroxide are pumped into the kettle simultaneously. The total charge of fat per kettle varies with the size of the kettle (40,000 to 60,000 pounds is normal, but in some cases the total may be 100,000 or more pounds). As soon as the dilute caustic mixes with the fat, saponification starts. The liquid mass is boiled by the admission of steam at the bottom of the kettle. As the saponification proceeds, stronger caustic is added gradually until the saponification is almost complete. The soap is then "salted out" or "grained out" by the addition of a large amount of ordinary salt; the sodium soap, being insoluble in the concentrated salt solution and of a lower density, rises to the top of the kettle, and the salt solution containing salt, glycerin, dirt, and excess alkali collects at the bottom of the kettle. The bottom brine layer is drawn off. Then water and an excess of lye are added to the soap remaining in the kettle. The mixture is boiled with steam to saponify the last traces of fat. The solution which collects at the bottom of the kettle during the subsequent settling process is drawn off. (It contains considerable amounts of alkali and can be used to start the saponification of a new batch of fat.) Brine is then added to the soap; the mass is boiled and allowed to stand until the "brine washed" soap rises to the top of the kettle. The brine solution at the bottom contains alkali and glycerin as well as salt; it is drawn off and the brine washing is repeated several times with fresh brine until the excess alkali and the glycerin in the soap are reduced to a minimum. All the various brine solutions are combined, purified, and evaporated, causing the salt to separate from solution and thus be made available for re-use in the soap kettle. After evaporation, the concentrated glycerin liquor which remains is distilled, bleached, and filtered, yielding chemically pure glycerin.

The brine-washed soap has a "grainy" appearance. It is "pitched" or "finished" by gradually adding water, while boiling, until the mass of soap loses its "grainy" appearance and becomes smooth. This treatment leads to the formation of two physical forms or phases of soap, namely, **neat soap** and **nigre.** The neat soap, also called *kettle soap,* is the pure end-product of the kettle process. Nigre is a dark-colored dense liquid containing a lower concentration of soap, along with much of the coloring matter and other impurities originally present in the fats used, and metallic (iron) soaps, excess alkali, and salt. These two phases of soap are normally immiscible, but they do not separate at this time because the mixture is vigorously agitated with steam. At the end of this operation, the "pitched" mass is allowed to stand, with the result that it gradually separates into two layers—neat soap on top and the heavier nigre on the bottom. The total time for settling and separation varies from 2 to 10 days, depending on the kind of soap and the size of the kettle. The neat soap that separates contains approximately 70 per cent soap and 30 per cent water. This proportion is a result of the natural physical equilibrium which develops between water, salt, and the soap in the kettle. It is independent, except in narrow range, of the raw materials used and the processing conditions, and hence cannot be altered by the manufacturer. During this treatment, it is possible to reduce the content of extraneous materials to a practical minimum; the resultant product is, consequently, *pure* soap. It is ready for further processing, depending on the kind of product that is to be made.

The kettle process is superior to the cold process in that soap of greater purity can be prepared; virtually all of the glycerin produced in the reaction can be recovered. However, the equipment used is extremely bulky, necessitating a great deal of plant space. Even more important is the time required for conversion of raw materials into the finished product; boiling, salting out, washing, and settling require a number of days before soap may be taken from the kettles. Further, it is not practicable to make coconut oil soaps or potash soaps by the kettle process; because of their great solubility, these soaps cannot readily be "salted out" as are the sodium soaps of higher molecular weight fatty acids.

CONTINUOUS SAPONIFICATION PROCESSES

The disadvantages of the kettle process have stimulated research on procedures whereby soaps can be manufactured more rapidly and with less bulky equipment. A process has been developed whereby fats and alkali react continuously to form soap, but little soap has been made in this way. More recently, a method has been devised for the continuous splitting of fats, by the autoclave method, into fatty acids and glycerin and subsequent saponification of the fatty acids into soap.

Hot fats and catalyst are fed continuously in at the bottom and hot water at the top of the autoclave. Very high temperatures (450° F.) and pressure (600 lbs./sq. inch) are maintained, causing the fats to split into fatty acids and glycerin. The fatty acids, being insoluble in and lighter than the water, rise to the top and are drawn off continuously; the glycerin, being water-soluble, falls with the water and is drawn off continuously from the bottom. The fatty acids, either in this form or after purification by distillation, are saponified with a suitable base to form soap.

This method has several distinct advantages over the kettle process. The following are the three most important: (1) The equipment necessary is not bulky, requiring only a fraction of the space required for kettle soap equipment. (2) Processing time is a matter of hours instead of days. (3) Greater flexibility is possible because soaps with any base (Na, K, etc.) and water contents over a wide range can be made by selecting the kind and concentration of base used to saponify the fatty acids, whereas by the kettle method only sodium soaps with approximately 30 per cent water can be made.

Most commercial soap still has its origin in kettles; for this reason the term **kettle soap** is still applied to that soap which is drawn as **neat soap** from the kettle or is made by the more modern continuous saponification.

CRUTCHING

The kettle soap is taken directly to the **crutcher,** so called because the stirring implement used by early soap makers for mixing soap resembled an invalid's crutch. **Crutching** is the process whereby the still molten or semi-liquid soap is mixed with any other ingredients which are to go into the finished product and is churned into a smooth mass. (At this stage, white floating soaps have sufficient air dispersed in them to reduce their density below that of water and thus enable them to float.) The nature and amount of added materials depend on the purpose for which the product is to be used; some of the more commonly used materials are as follows:

1. **Preservatives.** Most soaps contain an appreciable amount of unsaturated fatty acids and hence may, under some conditions, develop rancidity and show discoloration. To prevent this tendency, small amounts of preservative are ordinarily added to soaps. A commonly used substance is sodium silicate, but other inorganic and organic anti-oxidants are also used. When the proper kind and amount of preservative are used, the mildness of the product is not adversely affected.

2. **Essential Oils (Perfume Oils).** Nearly all bar soaps, and most flake and granulated soaps have some essential oils added. They may be used in amounts which only counterbalance the slight characteristic soap odor, or in amounts sufficient to give a dominant odor or bouquet, as in toilet soaps.

3. **Dyes and Pigments.** Certain toilet soaps have coloring matter of various kinds added. White pigments are also used in some toilet bars, since these products would otherwise have a translucency which would not be acceptable to the consumer.

4. **Superfat.** Before modern methods of soap manufacture were introduced, and before strict laboratory control was applied to the soap-making operation, it was difficult to produce soap in which the amounts of fat and alkali were exactly balanced. Since free alkali in great excess is harmful to the skin, it was an accepted procedure to use insufficient alkali for complete saponification, with the result that an excess of unsaponified fat was left in the finished product. This was known as superfat. The danger of the presence of free alkali was satisfactorily overcome in this manner, but the tendency toward rancidity was increased. The addition of excess fat, or superfat, is no longer necessary for the purpose of neutralizing alkali, but the practice of adding such material has none the less been continued to some extent for various reasons. Besides the usual soap-making fats, other substances such as lanolin, mineral oil, and cold cream have been used for superfatting soaps.

5. Builders. Builders are compounds which enable the soap to cleanse more efficiently. Among the builders in common use are sodium carbonate (or soda ash), sodium silicate, borax, trisodium phosphate, and sodium pyrophosphate. The kind and amount of builder used are chosen according to the purpose for which the soap is to be used and, so far as possible, the kind of water in which it will be used. Builders are used in practically all laundry soaps; they are not used in toilet soaps or soaps to be used for the washing of fine fabrics such as silks, nylons, woolens, and rayons.

6. Rosin. The familiar yellow laundry bars owe their special properties largely to the presence of rosin soap. Rosin is the residue remaining after the distillation of spirits of turpentine from the crude oleo-resin of certain species of pine. Rosin consists essentially of a mixture of complex organic acids (principally abietic) and esters, together with much extraneous material. Treatment of rosin with alkali yields a soft soap. Rosin soap imparts softness to laundry bars and makes them more soluble and faster sudsing in cool water.

7. Abrasives. Substances such as pumice, sand, talc, and borax are added to some soaps to increase their mechanical cleansing action. Some of these products are especially effective in removing heavy oil, grease, and other stubborn dirt from the hands. Bars containing finely ground pumice have been recommended for use on the skin in case of excessive oiliness, such as is seen in comedo acne.* Abrasive-containing pastes and powders are also on the market.

8. Germicides, Drugs, etc. Some compounds (such as mercuric iodide) are actively bactericidal when incorporated in soaps, and these products have a definite place under prescribed conditions. Many other materials, however, lose their germicidal effectiveness in the presence of soap and may even decrease the natural antiseptic properties of the soap. For instance, soaps containing cresylic or carbolic acid are less antiseptic than either the soap or the cresylic or carbolic acid alone when used in the same concentrations.

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* Becker, S. W., and Obermayer, M. E.: MODERN DERMATOLOGY AND SYPHILOLOGY, p. 517, Philadelphia, J. B. Lippincott Co., 1940.

FURTHER TREATMENT

After crutching, the soap is further processed in any of a number of ways, depending on the desired form of the finished product. The following are the most common forms:

1. **Framed Bars.** Some white floating soaps and all laundry bars are *framed* bars. They are made by pouring 1000 pounds or so of the molten crutched soap into large metal boxes with removable sides, known as frames. The soap is left in the frames until cool (3 to 5 days), the sides are removed, and, after further cooling until solid, the soap is cut into slabs and finally into bars. (See Figures 2 to 5.)

2. **"Continuous Process" White Floating Soaps.** One type of white floating bar is now being made by a continuous process instead of by the framing process. The crutched soap is rather rapidly cooled by appropriate equipment, and is extruded in the form of an endless bar, which is cut into convenient lengths. Because of the cooling, the soap quickly becomes firm enough to retain its shape and to undergo preliminary handling. After surface drying, the soap is cut to bar size, stamped, and wrapped.

3. **Flake Soaps.** Flake soaps are made by pouring the molten crutched soap over a rotating cold roll which spreads the soap in a thin film. This solidified film is cut into ribbons and scraped off the continuously rotating roll. The ribbons, which break up on drying to form flakes, are run through a dryer where the moisture content is lowered sufficiently to make the flakes handle easily and not mat in the package. (See Figure 6.)

4. **Milled Soaps.** Most toilet soaps are made by the process known as **milling.** The crutched soap is first flaked as described for flake soaps. The partially dried flakes are then run through a series of closely set granite or water-cooled steel rolls. As the finely compressed flakes come off the last

roll they are fed to a **plodder** which is quite similar to an ordinary meat grinder. The plodder forces the soap through a tapered nozzle in the form of a continuous compact bar, which is cut to desired size, stamped, and wrapped. (See Figures 8 to 12.)

5. Granulated Soaps. Soaps in finely divided form are made in either of two ways:

(a) A flake soap is made and then put into a grinder which breaks the flakes into small particles; or,

(b) The molten crutched soap is sprayed through a nozzle from the top of a tower. As the sprayed product falls, it is dried by a current of hot, dry air which removes moisture and converts the soap into tiny granules, usually puffed. The size of the particles may be controlled, within limits, by proper regulation of the process. (See Figure 7.)

The individual granules usually have an irregular spongy type of structure and hence the exposed surface is quite large. This results in rapid rates of solution and sudsing.

Kinds of Soap Products on Market

The various soap products used generally in the home can be grouped into six classes:

1. White Floating Soaps. These can be pure soaps, without builders, strong perfume, or coloring matter. These soaps can be made mild. They are used for many purposes—baby's bath, toilet, dishwashing, washing of fine fabrics (silks, woolens, etc.), and general household cleaning.

2. Toilet Bars. These do not contain builders, but do contain significant quantities of perfumes, and may or may not contain added coloring. If the perfumes are chosen carefully, and irritating materials are avoided, these products can be made mild.

3. Laundry Soaps—Bars, Flakes, and Granules. These contain builders added as a cleansing aid. In the case of the yellow bars, they also contain rosin. By selecting the proper kinds and amounts of builders, laundry soaps can be made of satisfactory cleansing efficiency and mildness. They are used extensively for laundry and general household purposes; they are used also for dishwashing.

4. Fine Fabric Soaps—Flake and Granule. These do not have builders, strong perfumes, or coloring matter added. They are particularly well suited for the washing of fine fabrics (silks, nylons, rayons, woolens, etc.); they are also used widely for dishwashing.

5. Abrasive Soaps. Bars containing fine abrasives are frequently used in the home both for skin cleansing and for other household purposes.

6. Liquid Soaps. Concentrated solutions of highly soluble soaps are used in the home mostly for shampoos. Similar products are frequently provided in washroom dispensers.

In addition to these soaps there are a great number of industrial soaps and soaps for special purposes.

III. THE NEW DETERGENTS

Most people think of any products that suds and cleanse as *soaps*. Included in the list of such products are all kinds of commercial soaps: pure white floating soaps, perfumed toilet bars, household soaps containing water softeners, and also a whole new class of sudsers and cleansers which, for want of a better name, may be called the *New Detergents*.

During the past fifteen years, literally hundreds of materials that cleanse have been synthesized. The research and development in this field have been directed toward overcoming the one important disadvantage of true soaps: their reaction with water hardness to form the insoluble *lime soap*. It was necessary, in addition, that the product have a satisfactorily high detergent power and that its cost of production enable it to compete with soap, at least in special applications. Despite these rather stringent requirements, much progress has been made. Now there are available a number of types of compounds which are used more or less extensively. There are both household products and industrial products.

For convenience of discussion, these detergents may be subdivided into three groups: anionic, cationic, and nonionic.

GROUP I. ANIONIC DETERGENTS

Some of the newer detergents are somewhat similar to soaps, chemically, in that they are salts of sodium, potassium, ammonia, or an organic ammonia derivative such as triethanolamine. The remainder of the molecule is usually a sulfuric acid derivative of an organic compound containing a long carbon chain. In aqueous solution, these substances ionize in much the same manner as do soaps; the ionization reactions are indicated in simplest form by the following equations:

$$\underset{\text{Soap}}{R{-}COONa}\ (\text{in } H_2O) \rightleftharpoons R{-}COO^- + Na^+$$

$$\underset{\text{An organic sulfate}}{R{-}OSO_3Na}\ (\text{in } H_2O) \rightleftharpoons R{-}OSO_3^- + Na^+$$

"R" in each case represents a long chain hydrocarbon radical, usually with seven to twenty-one carbon atoms.

Since the long chain (R) portion of the molecule bears a negative charge, these compounds, like soaps, are known as **anionic** detergents. They may be further classified chemically as **sulfates** and **sulfonates.**

1. **The sulfates** are characterized by the presence of the following type of structure in the molecule:

$$-C-O-SO_3M \qquad (M = \text{any suitable base})$$

The more important sulfates may be described as follows:

(a) *Alkyl Sulfates.* One of the first and most widely used of the new detergents is the type known as alkyl sulfates or sulfated alcohols. Fatty acids, or their esters, may be reduced, for example, by catalytic hydrogenation under high pressure, to form high molecular-weight alcohols. Treatment of the alcohols with sulfuric acid or other sulfating agent yields an alkyl sulfate, which on neutralization with a base forms a salt of the type indicated by the following formula:

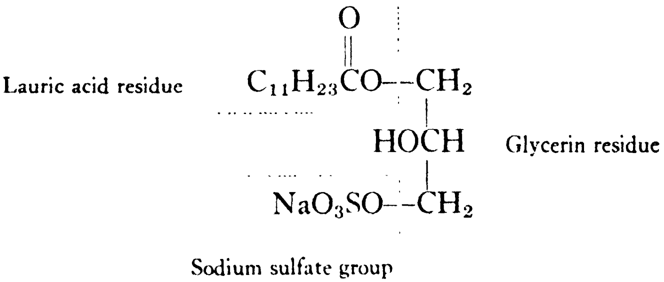
$$CH_3(CH_2)_{10}CH_2OSO_3Na$$

Sodium salt of lauryl sulfuric acid

In usual practice, coconut oil or another fat is reduced in the initial phase of the process, so that a mixture of fatty alcohols, and thus of alkyl sulfates, is produced.

These compounds have several conspicuous advantages over soaps for some purposes. They are approximately neutral in aqueous solution. They suds and cleanse in alkaline, neutral, and acid solution, and they do not form a scum in hard water. Whereas soaps combine chemically with calcium and magnesium salts forming an insoluble precipitate that is harmful to washing, alkyl sulfates remain useful sudsers and detergents in the presence of these salts.

(b) *Sulfated Esters.* The important representative of this type of detergent is the sulfated monoglyceride, represented by the following formula:



$$\begin{array}{r@{}l} C_{11}H_{23}\overset{\overset{\displaystyle O}{\|}}{C}O\text{--} & CH_2 \\ & \,| \\ & HOCH \\ & \,| \\ NaO_3SO\text{--} & CH_2 \end{array}$$

This product also gives neutral solutions and does not form a scum in hard water.

(c) *Sulfated Amides.* The sulfuric acid esters of certain nitrogen-containing compounds are also of some importance. A typical representative of this group of detergents is:

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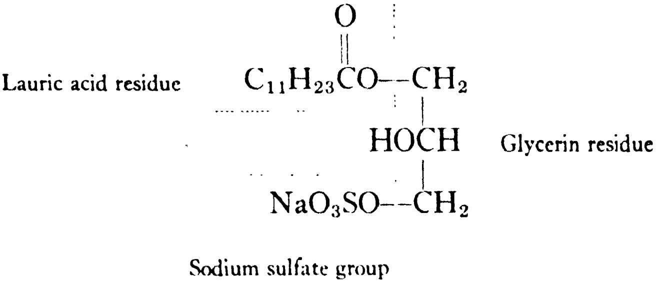
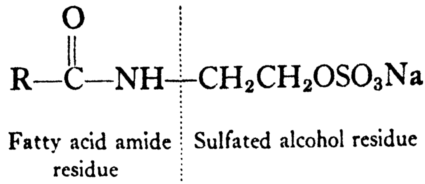
(b) *Sulfated Esters.* The important representative of this type of detergent is the sulfated monoglyceride, represented by the following formula:



$$\begin{array}{rl} C_{11}H_{23}\overset{\overset{\displaystyle O}{\|}}{C}O-- & CH_2 \\ & | \\ HO & CH \\ & | \\ NaO_3SO-- & CH_2 \end{array}$$

This product also gives neutral solutions and does not form a scum in hard water.

(c) *Sulfated Amides.* The sulfuric acid esters of certain nitrogen-containing compounds are also of some importance. A typical representative of this group of detergents is:



$$R\text{—}\overset{\overset{\displaystyle O}{\|}}{C}\text{—}NH\text{—}CH_2CH_2OSO_3Na$$

"R" again represents a long chain hydrocarbon radical, normally with seven to twenty-one carbon atoms.

2. **The sulfonates** are characterized by the presence of the following group in the molecule:

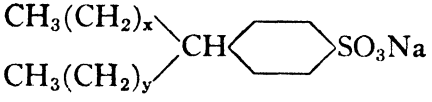
$$\text{—}C\text{—}SO_3M \qquad (M = \text{any suitable base})$$

They differ from the sulfates in that sulfonates contain a direct carbon-to-sulfur linkage, whereas, in the sulfates, carbon is connected to sulfur through an oxygen atom. The important sulfonates may be considered in several groups.

(a) *Alkyl Sulfonates.* Compounds of the type $R\text{—}SO_3Na$ have been made in which "R" is a long chain hydrocarbon group; a typical representative is:

$$C_{11}H_{23}CH_2\text{—}SO_3Na$$

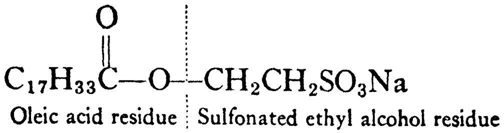
(b) *Alkyl Aryl Sulfonates.* More satisfactory detergents have been produced by the sulfonation of alkyl derivatives of aromatic (aryl) hydrocarbons, such as benzene, naphthalene, anthracene, and diphenyl. An example of this type of compound is illustrated by the following formula:



Many variations in chemical structure are possible with these products; several type are commercially available.

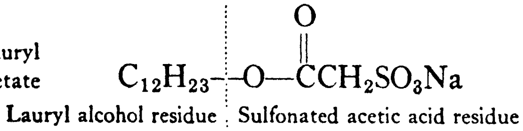
(c) *Sulfonated Esters.* Solubility of the alkyl sulfonates may be increased by the introduction of an ester group into the molecule. The sulfonic acid radical may be in either the acid or the alcohol portion of the ester. Typical examples are given on the next page:

Sodium sulfoethyl oleate



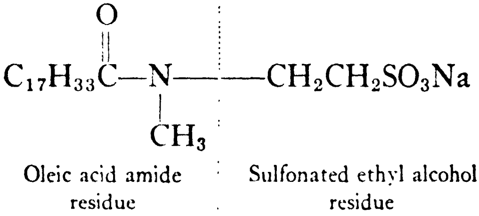
$$C_{17}H_{33}\overset{\overset{O}{\|}}{C}-O-CH_2CH_2SO_3Na$$

Sodium lauryl sulfoacetate



$$C_{12}H_{23}-O-\overset{\overset{O}{\|}}{C}CH_2SO_3Na$$

(d) *Sulfonated Amides.* The amide group also has the effect of increasing solubility, and various sulfonated amide derivatives have been prepared. The formula for one important example is as follows:



$$C_{17}H_{33}\overset{\overset{O}{\|}}{C}-\underset{\underset{CH_3}{|}}{N}-CH_2CH_2SO_3Na$$

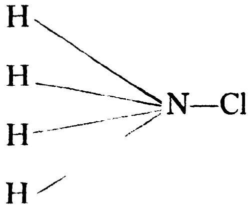
GROUP II. CATIONIC DETERGENTS

In the second group falls a series of compounds in which the important members are essentially ammonium salts with organic groups substituted for the hydrogen atoms. Ionization of this type of compound takes place as follows:

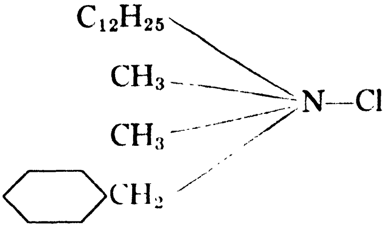
$$\underset{\text{Substituted ammonium chloride}}{R_4N-Cl}\ (\text{in } H_2O) \rightarrow R_4N^+ + Cl^-$$

Since the active, high molecular weight portion of the molecule takes a positive charge, these compounds are termed *cationic* detergents. In general, they are less important as cleansing materials than as wetting agents and germicides.

The relationship of these compounds to ammonium salts is brought out by the comparison of a formula for a typical member of this series with that of ammonium chloride.

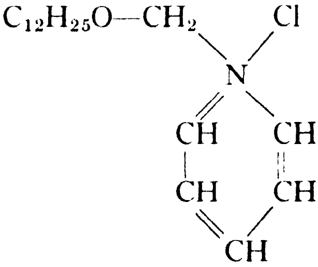


Ammonium chloride



Lauryl-dimethyl-benzyl ammonium chloride

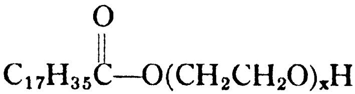
Cyclic compounds containing nitrogen have also been used to some extent. The following is an example:



Dodecoxymethyl pyridinium chloride

GROUP III. NON-IONIC DETERGENTS

Finally there is a class of surface-active materials which do not ionize in the presence of water and are consequently called *non-ionic* detergents. There are a number of different types of these compounds, such as ester and ether derivatives, that are good wetting and emulsifying agents, and some are useful as detergents. Representatives of this class are as follows:



$$C_{17}H_{35}\overset{\overset{\displaystyle O}{\|}}{C}—O(CH_2CH_2O)_xH$$

Ester of stearic acid and polyethylene glycol

$$C_{18}H_{35}—O(CH_2CH_2O)_xH$$

Ether of oleyl alcohol and polyethylene glycol

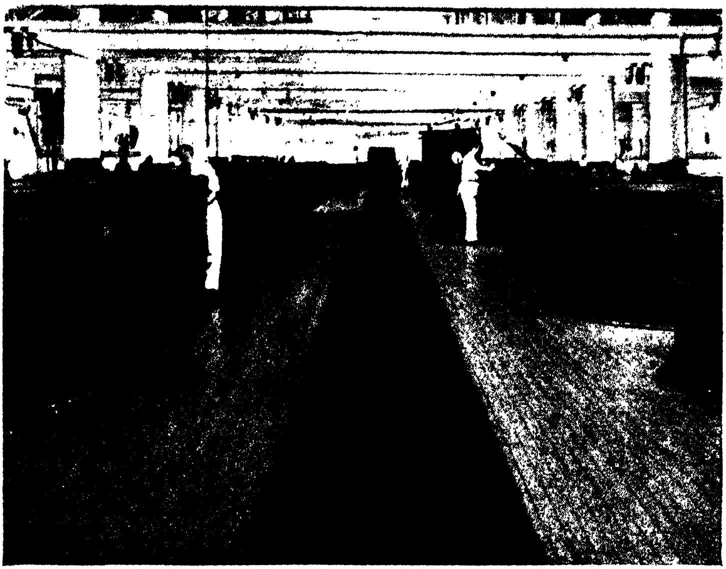
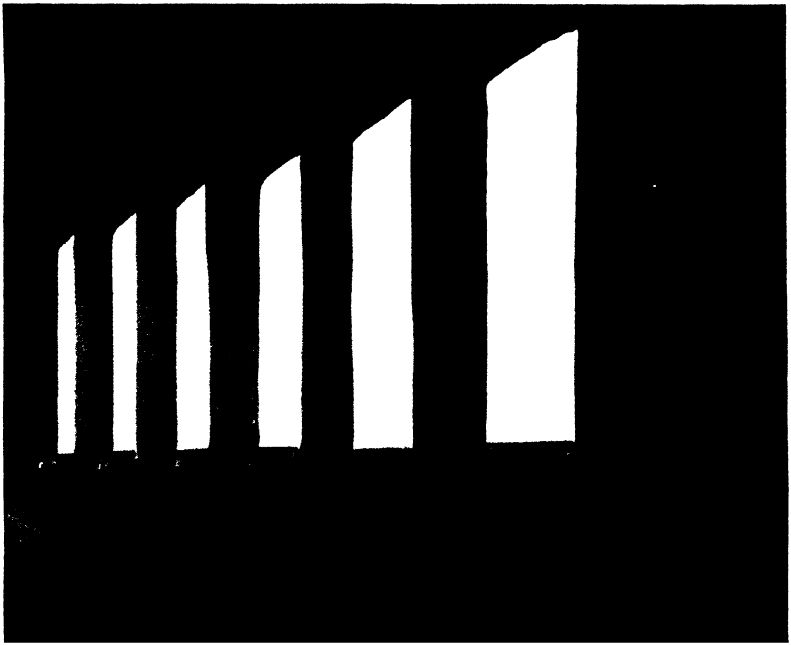


FIG. 1. Soap kettles. These soap kettles, the tops of which are shown here, extend downward for three stories.

FIG. 2. Manufacture of framed bars. Here molten soap flows from the crutcher, ready to be framed.



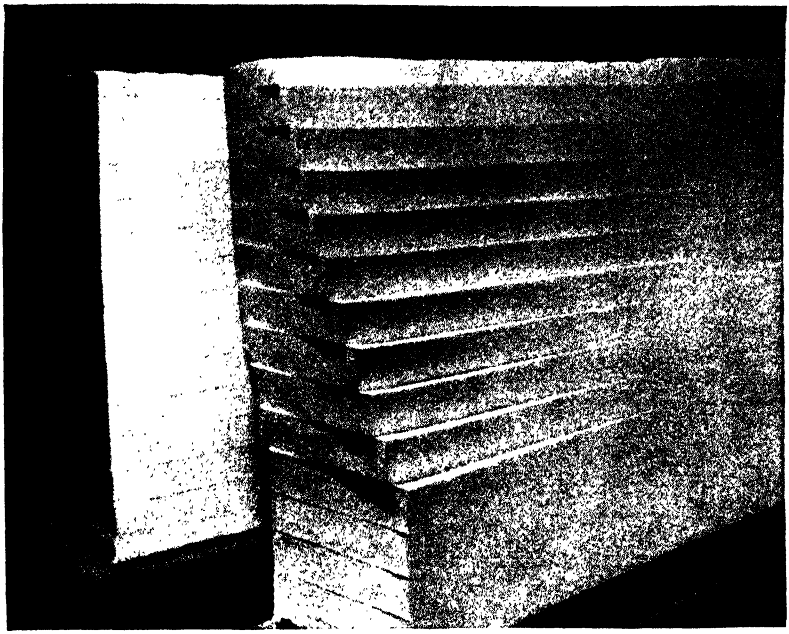
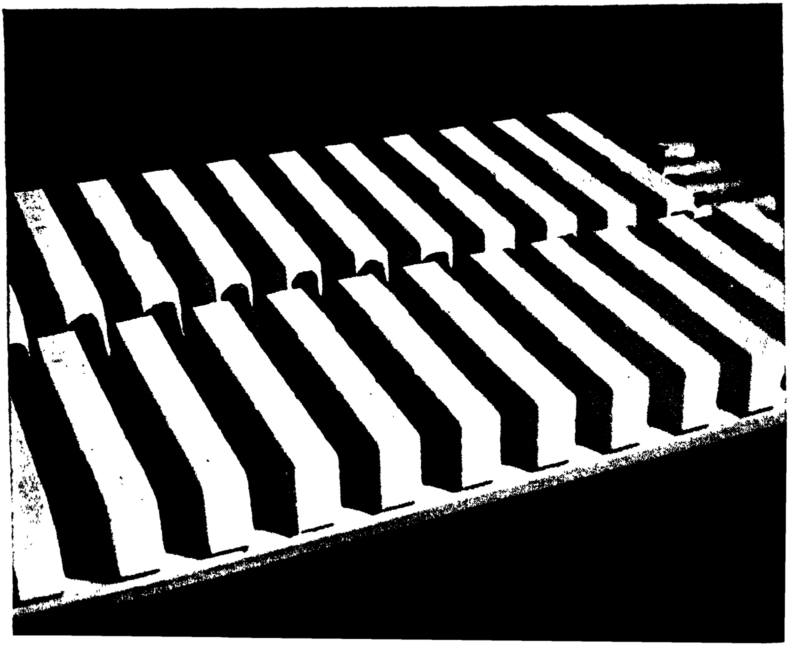


FIG. 4. Soap after the blocks have been cut into slabs by means of piano wires.



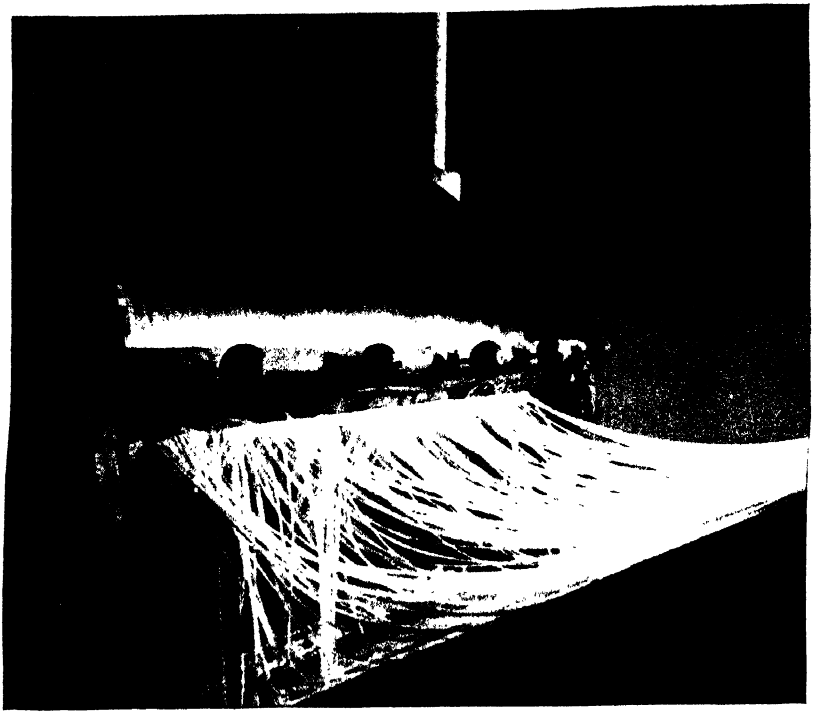


FIG. 6. Flake soaps. Ribbons of soap are scraped from the rolls, carried directly to driers, dried, and broken into flakes.

FIG. 7. Granulated soaps. Molten soap from the crutcher is sprayed in the top of a tower such as is shown here. As the soap falls, it is dried by a current of hot air and is thereby converted to tiny granules.

FIG. 8. In the manufacture of milled toilet bars, the crutched soap is converted to ribbons, then to flakes.

FIG. 9. In the actual milling operation the soap is passed between large rolls such as these.

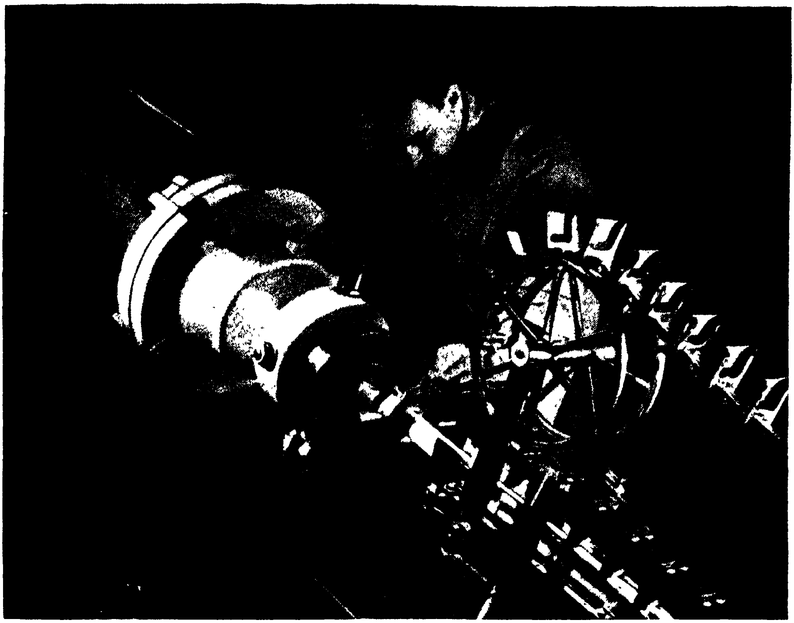


Fig. 10. The milled soap is then passed through the nozzle of the plodder in a continuous cylindrical bar.

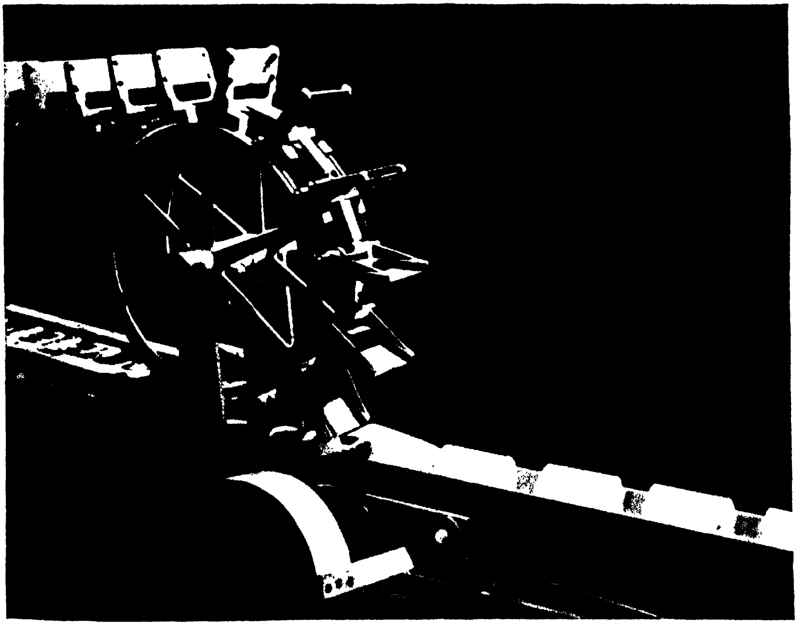


Fig. 11. The compact cylinder of soap is cut into sections of bar size.

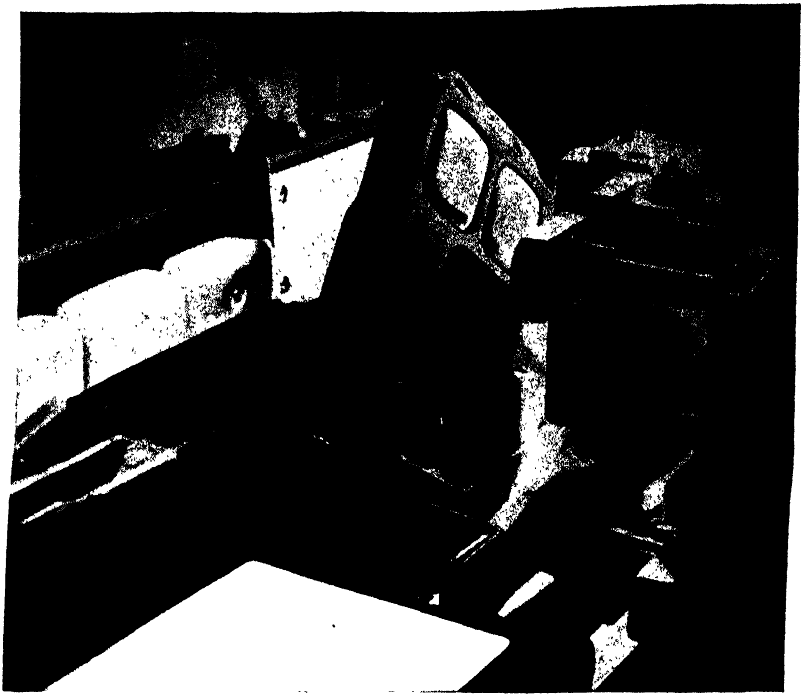


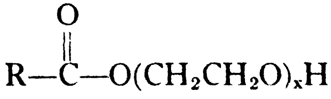
FIG. 12. The bars are then stamped into the desired shape.

IV. DETERGENCY OR CLEANSING ACTION

GENERAL PRINCIPLES

The most important function of soap is to remove dirt from dirty objects. Simple as this action appears, it is in reality complex, partially because of the varied nature of both **dirt and objects.** There appears to be little in common among such cleaning processes as the treatment of metals with acid before soldering, of laboratory glassware with a powerful oxidizing agent, of marble steps with sand, of greasy vats with lye, of suits of clothes with gasoline, and of the skin, fabrics, dishes, etc. with soap. Even the **dirts** which soap commonly encounters are widely different: perspiration on the body and on underclothing, hydrocarbons such as lubricating oil, saponifiable oils such as cooking fats, oil-coated soot from coal fires, non-oily dusts from country roads and fields, fruit juices, egg albumin, blood—the list can be extended at will. That soap should be effective over so wide a range of soils is truly remarkable. In accounting for this versatility, it is perhaps helpful to remember that **the primary cleaning agent is water; soap merely aids water to cleanse.** The way in which a detergent functions can be at least partially understood if we consider the architecture of its molecule.

The types of detergents that have been discussed may be represented simply by the following illustrative formulas:

Anionic	Soap	$R—COONa$
	Alkyl sulfate	$R—OSO_3Na$
Cationic	Substituted ammonium salt	$R_4\equiv N—Cl$
Non-ionic	Condensed glycol ester	 $R—\overset{O}{\overset{\Vert}{C}}—O(CH_2CH_2O)_xH$

In all cases, the molecule is characterized by a dissymmetry with respect to solubility in water; one portion of the molecule (the polar portion, such as –COONa, $-OSO_3Na$, etc.) is water-soluble, while the other portion (the non-polar fraction, represented by R–) is soluble in fats, oils, and fat solvents but not in water. Long hydrocarbon chains are the most typical examples of non-polar (R–) groups.

Because of this unsymmetrical configuration, the detergent molecules have a strong tendency to concentrate in the surface of aqueous solutions, thereby lowering the surface tension. Symbolically, the condition may be represented as in Figure 13; the molecule of detergent is represented by O—, where the "head" (O) is the polar or water-soluble group, and the "tail" (—) is the non-polar or fat-soluble group. The molecules in the surface are oriented so that the water-soluble fractions extend downward into the solution while the fat-soluble portions tend to remain at the surface.

In the presence of fatty material, the configuration of the detergent molecule assumes further importance. In an emulsion of oil in water, the orientation of the detergent molecules around an oil droplet is illustrated diagrammatically in Figure 14, the symbols being the same as those previously used. The oil is held in suspension by the detergent, the droplets being surrounded by an oil-repellent film which prevents their coalescence.

The cleansing action of detergents can be explained to a large extent on the basis of these phenomena. Under ideal conditions (i.e., in warm soft water), it is probable that the washing process takes place somewhat as outlined in the description which follows. The various steps depicted do not necessarily take place in the given sequence; they are more likely to occur simultaneously, mutually supplementing one another.

1. The detergent, on dissolving, lowers the surface tension of the water. This permits more intimate contact between the water and the material to be cleansed (fabric, skin, etc.), and enables the solution to penetrate between the material and the particles of soil.

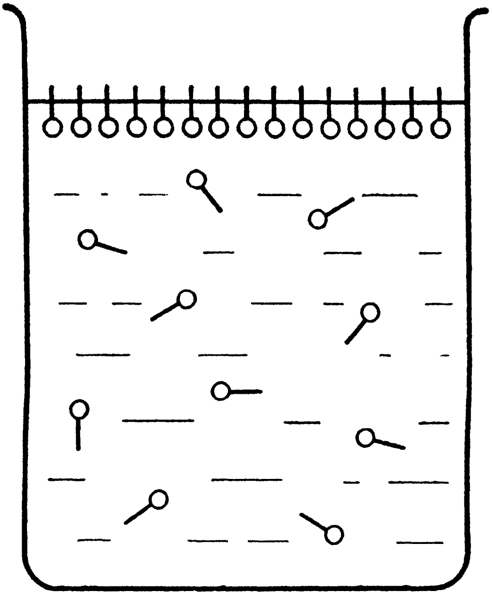


FIG. 13. The distribution and orientation of soap molecules in aqueous solution.

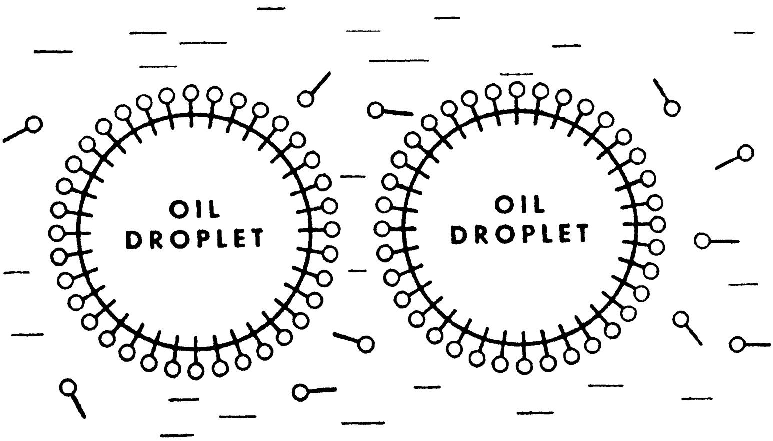


FIG. 14. Soap molecules emulsify oil droplets and prevent their coalescence.

2. The solution emulsifies and to some extent dissolves any grease or oil that may be present.
3. Insoluble particles of dirt are wetted, surrounded, and held in suspension by the detergent solution.
4. Mechanical action aids in loosening the soil from the surface to be cleaned.
5. The solution and the suds or lather, containing emulsified or dissolved oil and grease and suspended dirt, are rinsed away.

General Factors Influencing Detergency

The efficiency of cleansing is influenced by a number of factors, including the nature of the detergent, the presence of builders, temperature, washing time, mechanical action, and water hardness.

In general, the higher the molecular weight of the long carbon chain in the detergent, the more efficient is the detergent. Solubility in water, however, decreases with increasing molecular weight, so that this property must also be considered; i.e., the detergent must be sufficiently soluble under the desired conditions to give satisfactory results.

The efficiency of true soaps, as well as of some other types of detergents, is increased by the addition of **builders.** These materials aid the detergent, regardless of the water hardness, by neutralizing acidic substances and by lowering the interfacial tension between soap solution and oily material, thus aiding in dispersal of the oil. In this manner, builders reduce the amount of soap required for a given washing operation.

Detergency tends to improve with increasing temperature and, up to a certain point, with increasing time of contact. Mechanical action, supplied either by agitation or by rubbing, is an important aid in almost all types of cleansing operations.

Water hardness affects the detergent efficiency of true soaps and the new detergents quite differently. The amount of soap required for cleansing increases progressively with increasing water hardness, while the amount of the new detergents required is affected only slightly by the degree of hardness of the water. This difference results from the fact that soaps, but not the new detergents, react with certain salts present in hard water to form insoluble lime soaps. Not only does this reaction convert a portion of the soap to an insoluble product which is useless as a cleansing agent, but extra soap must be used to hold the precipitate in suspension and prevent its deposition on the material to be cleansed. The alkaline builders used in many soaps react with a part of the soap-consuming ions in hard water to form either unionized soluble salts or precipitates; in this way builders relieve the true soap of a portion of the burden imposed by water hardness.

Factors in Specific Cleansing Operations

In removing soil from the skin, the situation is somewhat different from that encountered in most other washing procedures. In this instance, cleansing is carried out largely by **lather,** a rather concentrated (5% or 6%) soap solution, rather than by a fairly dilute solution. The application of lather is a convenient way to bring a large amount of soap into intimate contact with the skin surface and thus to permit speedy cleansing. A large part of skin cleansing is dependent on mechanical action, i.e., rubbing; for this reason, abrasive materials are sometimes added to bar soaps intended to aid in the removal of heavy, greasy soil from the hands. Mildness is, of course, a primary factor to be considered in the manufacture of soaps for use on the skin.

A much lower concentration of detergent (a few tenths of one per cent) is ordinarily employed in washing fabrics, but the time of contact is considerably longer. Besides aiding in the removal of soil from the material, the detergent has the additional function of keeping the dirt suspended in the solution and thus preventing its re-deposition on the fabric.

The suds serves as an indicator of the amount of active detergent available for the cleansing process. Mechanical action is usually supplied by agitation.

Dishwashing, as well as the washing of woodwork, floors, etc., is rather largely mechanical. The detergent increases the ease with which the soil is removed and prevents the soil from being re-deposited on the surface. The concentration used is of the order of a few tenths of one per cent. As in fabric washing, the suds serves as an indicator of the presence of sufficient detergent to carry out a satisfactory washing operation. Since the hands are in rather prolonged contact with the solution, mildness must receive consideration in designing detergent products for dishwashing purposes. Further, the detergent must dissolve readily at a temperature which can be borne by the hands.

2

Usual or Normal Effects of Soap on the "Normal" Skin

MARION B. SULZBERGER, M.D.
and
RUDOLF L. BAER, M.D.

Proper cleansing can remove from the human skin many primarily irritating, sensitizing, toxic and poisonous agents potentially harmful to the skin itself or which, by their absorption through the skin, might become harmful to other organs or to the body as a whole. Furthermore, proper cleansing can remove microorganisms and other living agents of disease which might otherwise cause persistence, recurrence, or spread of the infection in the individual, or transmission of infection to others.

Of the many procedures which are available for cleansing the human skin, washing with soap and water has been, and undoubtedly still is, by far the most commonly employed. Soap and water washing is one of the most pleasant, most readily available, and most effective and generally harmless of cleansing methods.

The normal skin is continually coated with a covering, which varies in thickness, physical state, and chemical composition, but which always consists of a mixture of materials. These originate from two sources:

1. Autochthonous or endogenous substances, i.e., those produced by the individual himself; and
2. Exogenous substances, i.e., those coming from the outer world.

The use of soap and water aims primarily to remove all exogenous materials deposited on the skin surface, as well as a part, at least, of the materials which have been produced, excreted or secreted by the skin itself and which, for one reason or another, are no longer considered "desirable." Some of the exogenous materials on the skin surface usually become mixed with the skin's own products and form the more or less adherent "dirt" or "soil" (Lane and Blank).

An understanding of the action of soap and water on the human skin necessarily depends on a knowledge of the structure of the cutaneous surface, of the autochthonous covering that envelops most of this surface, and also of the exogenous materials deposited and eventually mixed with this autochthonous mantle.

THE NATURE OF THE CUTANEOUS SURFACE AND THE ORIGINS OF ITS COVERING MANTLE

The reciprocal effects of the use of soap and water and of subsequent changes in the deeper layers of the skin (such as increase and decrease of bloodflow, of pigmentation, of the thickness of the prickle cell layer), have not yet been sufficiently studied to warrant conclusions as to their true significance. Studies on the effects of soap on the skin have been almost exclusively confined to investigations of the more direct action on the horny layer and its covering mantle.

AUTOCHTHONOUS MATERIALS OF THE COVERING MANTLE

The horny layer is formed by those epithelial cells which have died and undergone cornification; these, when they reach the skin surface, are shed more or less rapidly. The dead and cornified cells (horny cells), mixed with the secretions of the cutaneous glands and with the fluids and substances diffusing through the skin, together with extraneous materials from the outer world, eventually form the covering mantle. The horny cells consist principally of proteins (mainly keratin), lipids, and water. When undisturbed, their arrangement in the horny layer is somewhat similar to that of shingles on a roof. The reaction of the horny cells is more acid than that of any other cutaneous tissue. This probably contributes to a significant degree to the maintenance of the normal "acid mantle" which almost all investigators agree to be the physiologic and desirable covering of the skin's surface. Other factors that contribute to the surface acidity are the fatty acids of the sebum, and particularly, acid sweat. The diminution of sweat during cold weather is a possible explanation of the increase of susceptibility to irritation by soap during periods of low temperature. The "acid mantle" is considered to be essential to the health of the skin. This is one of the prime factors to be remembered when considering the effects of soap.

The thickness of the horny layer varies considerably in different persons. It also varies from time to time in the same person. It is thick during the first few hours up to a day or so after birth (Miescher) and thin during the remainder of infancy. It tends to thicken at puberty and to thin out in old age. Furthermore, its thickness varies greatly in different body regions. As a rule, the horny layer is thickest on the palms and soles. The horny layer generally thickens in areas exposed to constant friction, to other trauma, to light, and chemical irritation.

Even the mechanical arrangement of the horny cells in the shingle-roof-like structure may be of importance in protecting the body and in determining the rate of penetration of foreign substances, including soap, into the epidermis and deeper structures. Even the slightest disturbance of the normal shingle arrangement, such as is produced by slight friction or scratching, may cause a loss of normal resistance to penetration by potentially damaging agents.

A number of investigators (Stauffer, Hansen, Lustig and Perutz, Pillsbury and Shaffer) have demonstrated that the horny layer of the human skin is much more sensitive to alkalis than to acids. This is not surprising when one considers the fact that the pH of the "normal" cutaneous surface is always within the acid range (3.7 to 7.0 according to a number of investigators—Schade and Marchionini, Lane and Blank, and others); and that clinical experience has shown that alkalis are much more likely to produce lasting or severe cutaneous damage than are acids.

The secreting glands, whose ducts empty onto the cutaneous surface, are of three varieties:

1. The eccrine sweat glands;
2. The apocrine glands, and
3. The holocrine sebaceous glands.

The products of the sweat glands consist mainly of watery solutions (of mineral salts, organic acids, urea, etc.) plus small amounts of fatty matter. Certain substances can be selectively excreted through the sweat glands, e.g., ammonia, uric acid, creatinin, chlorides, phosphates, sulfates, bromine, mercury, sulfonamides and certain vitamins (Way and Memmesheimer, Cornbleet and others).

The eccrine sweat glands are distributed all over the cutaneous surface, with the exception of a few areas on the genitalia, the nails, and the ears.

The apocrine glands secrete material similar to that of the eccrine sweat glands; but are, in addition, probably the chief producers of the odoriferous cutaneous secretions. The apocrine glands are located principally in the axillae, the mons veneris, the prepuce, the perianal areas, the abdomen, and about the nipples. They develop and start functioning at puberty.

Among the most important contributors to the formation of the covering mantle of the skin surface are the sebaceous glands. The secretion of these holocrine glands is composed of the disintegrated whole gland cells and forms the major part of the sebum, i.e., the oil, fat, and grease of the skin's surface. The sebum contains only small quantities of true fats, but consists chiefly of the esters of the high molecular-weight alcohols and fatty acids, with some free cholesterol.

The sebaceous glands are distributed over the body surface wherever there are hair follicles; and, in addition, in some regions which do not possess hair follicles, such as the glans penis, the prepuce, the clitoris, the labia minora, the nipples, the areola, and the lips, as well as in some other sites.

Sebaceous glands are notably absent on the palms and soles. The fact that the palms and soles lack the sebaceous part of the covering mantle, while possessing the thickest horny layer, is especially noteworthy when the effects of soaps on these regions are considered.

SUMMARY

The autochthonous, body-formed products, which contribute to the normal mantle of the skin's surface, include:

1. Dead horny cells, and the materials derived from the alteration and disintegration of those cells.
2. Sweat, with its salts and other constituents.
3. The secretions of the apocrine glands.
4. The secretions of the sebaceous or oil glands.
5. Substances diffusing or otherwise passing through the skin from within and reaching the skin's surface.
6. Minor adjuvant materials, such as cerumen from the ears, smegma from the prepuce, dead materials derived from hairs and nails, etc.

EXOGENOUS MATERIALS OF THE COVERING MANTLE

The exogenous materials which may be found on the cutaneous surface comprise all the substances encountered in the environment of human beings. These innumerable substances can be divided into water-soluble, oil-soluble, and insoluble substances (Lane and Blank). For the sake of convenience, it may be assumed that the exogenous materials on the human skin surface belong, as a rule, to one of the following groups:

1. Airborne materials (dusts, pollens, condensation products of vapors, smokes, etc.);
2. Materials which are deliberately brought into contact with the skin (clothing, bedding, cosmetics, topical medicaments, etc.);
3. Materials encountered in occupational activities, hobbies, etc.;
4. Micro-organisms and virus (bacteria, fungi, herpetic and other virus, etc.).

THE DEGREE TO WHICH CLEANSING OF THE SKIN IS DESIRABLE

Why is it desirable completely or partially to remove the different constituents of the material on the skin? Obviously it is more beneficial to remove certain constituents of the skin's mantle than others. While it is commonly desirable to remove all or most of the exogenous material present, the removal of the autochthonous portions of the covering mantle is usually desirable only when:

1. The autochthonous materials have become inseparably contaminated with living or dead exogenous materials, which should be removed;
2. The autochthonous materials are present in abnormal amounts or forms;
3. The autochthonous materials have become objectionable through alterations which have produced unesthetic, irritating, or toxic phenomena.

Regrettably, there is no available cleansing method through which sharply directed fractional removal can be practiced: i.e., it is not possible to take away only the undesirable parts of the mantle and leave the desirable ones.

A too frequent or too thorough removal of the covering mantle tends to deprive the skin of its essential lubricating and protecting covering, thus exposing primarily the skin—and secondarily the entire organism—to the effect of potentially harmful substances. The products which have been deposited by the skin itself on its surface form the outermost defenses of the human body against its environment. While this shield-like protective action is perhaps its most important function, there are still other ways in which the film formed at the body's surface is of value (irradiation of sterols and reabsorption as vitamin D; bactericidal substances, etc.). Fortunately, this natural film is being constantly renewed and reinforced.

THE GENERAL MECHANISM OF SOAP ACTION ON THE SKIN AND ITS COVERING MANTLE

Since soap is always used in conjunction with water on the human skin, the mechanism of soap action must be discussed in terms of the effects of aqueous suspensions and solutions of soap. The theoretical explanation of this mechanism has undergone numerous changes during the past decades. As Fall pointed out, "innumerable theories have been proposed by innumerable investigators." It will suffice to mention here that almost all the "older" theories on the mechanism of soap action were based on the assumption that the soaps' cleansing and wetting action was attributable almost exclusively to the alkali (free alkali, plus alkali which is always liberated when soap is hydrolized in water).

Even today the exact nature of the detergent action of soap on the human skin is not fully understood. Furthermore, while the detergent action of soap is only one of its several effects on the skin, it is the most important effect and the one on which most of the other effects are dependent.

Sodium soaps are, of course, those which are almost universally used for cleansing purposes on the human body, and unless otherwise specified our remarks apply to these particular soaps.

It is assumed that soap emulsifies both water-soluble and fat-soluble materials present on the skin surface, including both the exogenous materials and the autochthonous products. Since the mechanisms of emulsification are detailed elsewhere in this volume, we need only mention that the emulsification produced by soap is based on the presence of lipophilic and of hydrophilic groups in the molecule; and that these groups permit contact between the water-soluble and fat-soluble materials. The lipophilic groups are present in the form of the fatty acids. In general, a high molecular weight of these fatty acids aids detergent action on fatty materials.

Once the materials on the skin surface have been emulsified in the aqueous soap solution on the skin, rinsing with additional water brings about a constant dilution and removal of the remaining soap solution, together with the materials emulsified in this solution. Thus, both the degree of cleansing and the amount of the soap remaining on the skin after washing depend directly on the amount of rinsing carried out at each particular washing.

The present-day concept of the cleansing action of soap may be expressed as follows: The emulsifying action of the soap-in-water solution leads to a rupture of the interface between the skin itself and the materials deposited on the skin. In place of this interface, interfaces between the skin and the soap solution and between the removable materials on the skin surface and the soap solution are established.

This, therefore, presents two ways in which insoluble materials on the skin are removed:

1. The emulsification and removal of the soluble materials, which contain insoluble materials in mixture or suspension, will simultaneously bring about the removal of the contained insoluble materials; and

2. The wetting action of the soap solution effects a loosening of the sorption compound formed by the insoluble materials and the cutaneous surface, and thus permits and facilitates their removal.

In addition to these two effects, there are others inherent in the washing procedure itself: for example, the mechanical removal of insoluble particles by the rinsing process, by friction, by foam and suds, etc.

As stated the described detergent action of soap and water is not highly selective; it will remove not only exogenous materials, but also a greater or lesser portion of the autochthonous materials. But the amounts removed, and to some degree the quantitative ratios between the components removed, depend on a number of factors. Only a few of these factors seem to warrant mention here, namely: the character of the skin itself, the nature of the covering mantle and soil, the type and quality of the soap used, the length of exhibition of the soap solution on the skin, the amount of soap and water used, the composition and temperature of the water, the quality and quantity of mechanical action supporting the soap action, the amount of rinsing, the mode and thoroughness of the drying action following the washing, etc., etc.

In addition to its detergent action, i.e., its removal of portions of the exogenous and autochthonous mantle, soap and water washing exerts a definite influence on the cutaneous tissue itself. Under normal conditions, the action on the skin is limited to the uppermost layers of the attached horny cells and is not noticeable clinically. The effects of soap solutions on the horny layer depend, to a great extent, on the following properties:

1. The quality of the soap, particularly as it relates to the absence of free alkali, or to a somewhat lesser extent, the absence of alkaline salts (builders).
2. The particular mixture of fatty acids present, and
3. The conditions under which the soap is used, particularly as they relate to temperature, concentration, and duration of contact.

EFFECTS OF ALKALI IN SOAP

The soft and slippery or satiny feeling which ensues after washing the hands with soap and water is probably due partially to a deposition of calcium soaps but mainly to a liquefying or swelling and softening effect of the alkali upon the topmost cells of the horny layer. This pleasant "feel" of the skin may thus actually be a sign of mild superficial damage. It is not astonishing, therefore, to find that, when too often repeated or too long continued, this damage may eventually manifest itself in the form of roughness or scaling and ultimately by irritation and redness.

Whenever the skin is washed with soap and water, the resulting alkalinity of the skin surface persists for varying periods of time until the skin is able to reestablish the normal acid reaction of its surface. The time required for the reestablishment of normal acid reaction varies tremendously from person to person, from skin to skin, from site to site, from time to time, from climate to climate, and season to season.

The alkalinizing action of soap depends on the amount of alkali present in the solution; and this, in turn, depends on:

1. Free alkali,
2. Alkali liberated by hydrolysis, and
3. Alkali derived from builders, etc.

The so-called "neutral soaps" ordinarily do not contain more than a trace of free alkali. Government specifications for *toilet* soaps say that the free alkalis must not exceed one-tenth of one per cent. In fact, few *laundry* soaps contain up to the permitted one-half of one per cent free alkali. The neutral soaps and the household and laundry soaps differ primarily in that the neutral soaps do not contain builders such as are contained in household and laundry soap.

The amount of alkali liberated when the soap is hydrolized is assumed to be of much greater practical importance than the quantity of "free" alkali. Soaps are composed of salts of weak acids (fatty acids) and strong alkalis (sodium or potassium hydroxide). Since the strong alkali is more strongly ionized than the weak acid, an alkaline solution invariably results on hydrolysis. The degree of hydrolysis of a soap depends on the particular fatty acids and alkalis present, and on the degree of dilution of the soap solution. Progressive dilution first increases and then decreases the ionization of the fatty acids and alkalis.

As stated, the effect of alkali on the horny layer of the skin is expressed by swelling and by some solution of the horny cells, which subsequently lead to a drying and loosening of these cells. The greater the number of cells removed and scaled off in this way, the thinner the remaining protective horny layer, and the greater the chance for the soap to affect the subjacent layers at subsequent washings. In this way, too, penetration and damage by substances other than soaps is facilitated. Thus the effects are both additive and cumulative.

The increased speed of penetration which can be produced by soap is employed therapeutically by the use of soap applications or scrubbings prior to the application of medicaments designed to penetrate into the skin.

It is doubtful whether the "normal" use of soap and water for washing is capable of bringing about any significant swelling of the horny cells of a "normal" skin. It may be assumed that, if there is any such swelling from "normal" use on "normal" skin, it is very likely to be negligible and unlikely to produce pathologic changes. Only when the skin is abnormally sensitive, or when the soap is abnormally employed, or when other additive factors are present, will damage result from washing with a properly compounded and correctly manufactured toilet soap.

SOME ADDITIONAL EFFECTS OF INGREDIENTS OF SOAPS

The previously described effects may be regarded as the "essential" or "characteristic" effects of soap. However, most soaps contain ingredients which are designed to add to and to go beyond these essential effects. Some of these ingredients improve soaps from the esthetic viewpoint.

Thus, dyes are often added to give a certain color, to improve the appearance of the soap, and to strengthen its appeal to the potential customer.

Glycerine, sugar, alcohol, and castor oil may be added to create a transparent soap.

Perfumes are added in varying amounts in order to impart a pleasant scent.

Small amounts of silicates are sometimes incorporated to prevent rancidity; larger amounts of silicates are combined in special-purpose soaps as fillers or builders which harden the soap, improve its texture, and add to its lathering, emulsifying, and detergent qualities (Klauder et al.).

> Still other ingredients are incorporated in soaps designed for specific purposes. Thus, the special household and laundry soaps often contain significant quantities of builders. Then there are the mechanics' soaps and scouring soaps to which abrasives are added (such as pumice and sand), superimposing mechanical removal of materials from the skin surface to the physico-chemical action of the soap-solution itself. The medicinal soaps are those to which antiseptics or other therapeutic remedies are added (tar, tar extracts, sulfur, mercury, cresols, etc.), giving the soap varying degrees of medicinal and therapeutic action.
>
> "Superfatted" soaps are those to which lanolin or other fats are added in quantities beyond those required to produce a neutral soap. The excess fat is supposed to replace on the skin surface that part of the oil which has been removed by the detergent effect of the soap. This effect has not been scientifically established. Furthermore, it was originally believed that the excess fat might neutralize both the free alkali and the alkali which always results from hydrolysis—a theory which has since been proven to be untenable.

GENERAL REMARKS ON THE BENEFICIAL EFFECTS OF SOAP

The Germicidal and Antiseptic Action

The beneficial action of soap and water on the skin has long been recognized, particularly in medicine, where "scrubbing up" is still the standard sterilizing procedure for surgeons. However, the precise nature of this antiseptic action is not, as yet, fully understood. All observers seem to agree that the principal way in which soap and water help to reduce the number of bacteria present on the cutaneous surface is simply by removing the microorganisms, just as other insoluble materials are removed by washing.

There is evidence, however, that the antibacterial action on the skin is not confined to this detergent effect, but that soap and water exercise additional functions. Thus, soap solutions have been found to be good germicides for certain bacteria (streptococci, pneumococci, meningococci, diphtheria bacilli, influenza bacilli, spirochetae pallidae), while they are poor germicides for others (staphylococci, typhoid bacilli). This germicidal action takes place in dilutions of soap in water of from 1 : 80 to 1 : 1280. In this connection, it is to be noted that Walker reports that a thick lather of soap and water on the skin represents approximately a 1 : 12 dilution; while Klauder and associates state that soap solutions, as usually employed, represent a concentration of approximately 1 per cent. Dishwashing and laundry solutions may vary from 0.3 to 1 per cent or slightly more. Based on the germicidal concentrations, as determined by in vitro experiments (1 : 80 to 1 : 1280), either the 1 : 12 concentration reported by Walker or the 1 : 100 concentration reported by Klauder et al., might well be effective as germicidal agents.

Walker also finds that the germicidal activity increases with increasing temperature of the water used in the solution. Furthermore, the pH of the medium in which the soap acts on the bacteria appears to be of some importance, the low molecular-weight fatty acids being more germicidal in acid media, and the high molecular-weight fatty acids being more germicidal in alkaline media. The particular pH at which a given fatty acid exercises its optimum bactericidal action appears to depend on the type of microorganism involved.

In addition to the germicidal effect, a detoxifying effect has been attributed to soap. Larson and Nelson found that, when castor-oil soap was added in sufficient quantities to tetanus or diphtheria toxin, these toxins were entirely detoxified. This effect has been attributed to the soap's tendency to bring about a marked decrease in surface tension. Similarly, anti-viral action of soap solutions has been demonstrated. (See for example studies of Stock and Francis.)

Some observers have postulated that the antibacterial effects may be due, in part, to the action of soaps on the fatty substances in the capsule of certain microorganisms.

While the bactericidal, virucidal, and detoxifying action of soaps still requires much practical experimentation, the function of soap in removing bacteria from the skin has received substantial experimental support. Interesting studies of this action have been carried out by Price, who demonstrated the quantitative reduction in the bacterial flora after soap and water washing of the cutaneous surface. According to this author, the bacterial flora on the skin surface may be divided into:

1. A transient flora, which varies greatly in number and kind of microorganisms and which is found mainly on the exposed parts of the skin; and
2. A resident flora, which is relatively stable and persists for longer periods on the protected or covered parts of the skin.

The transient flora contains more pathogenic microorganisms than the resident flora. Moreover, the transient flora and its pathogens are quite readily removed by soap and water washing; while the resident flora can be removed only with difficulty. Every six minutes of scrubbing with soap and water reduces the quantity of transient flora by some 50 per cent. The vigor of the scrubbing is the most important factor influencing the effectiveness of the bacteria-removing action.

Regardless of the kind of soap or other detergent used, and regardless of the frequency and thoroughness with which the scrubbings are performed, the bacterial flora can never be reduced to zero. Price did not find any significant difference in the capacity of different types of soaps to remove bacteria. Pillsbury and coworkers, who studied the effects of washing with the newer emulsion creams and water, found that these also removed microorganisms; and that this effect was similar, but not superior, to that achieved with soap solutions.

Largely because of its capacity to remove great numbers of microorganisms from the skin surface, from the crypts, folds, and fissures of the skin, from the hairs, from beneath the nail-edges and from around the nails, etc., and perhaps also because of its direct antiseptic action, soap and water washing is a very real and valuable medical and sanitary procedure. This procedure is being employed constantly, not only by the ordinary citizen and notably by the surgeon, dentist, nurse and medical attendant, but also as a routine and essential part of *venereal disease prophylaxis*. There is little doubt that immediate soap and water washing of the exposed parts of the skin and transitional mucous membranes is a powerful preventive of many venereal infections. Plenty of soap and hot water are today recognized as being fully as important as other procedures. (This clinical fact holds true, even though the recent experiments of Greenblatt and coworkers may, if confirmed, cast some doubt on the long-accepted clinical conclusion regarding the efficacy of soap and water in preventing chancroidal infections.)

In addition to the direct medical effects, there are other benefits derived from the use of soap and water—benefits as undeniable as they are sometimes intangible. Washing and scrubbing with soap and hot water often makes the individual look and feel better. The ablutions actually do remove the horny plugs, the sebum and the dirt from follicle openings and pores, and remove the detritus from the surface; and do perhaps, in these ways, promote the functions of excretion and secretion by the skin glands and the functioning of other skin cells. But whether or not these effects be as direct and simple as just expressed, no one will challenge the statement that the man, woman, or child who steps from the shower or hot bath, after the liberal use of soap-suds and thorough rinsing, not only presents a more esthetic and healthy picture, but actually feels better. Those who have been deprived, for one reason or another, of the use of soap for days or weeks or months, will testify that this deprivation constitutes a significant cause of discomfort and produces a very real reduction in the sense of well-being. The use of water alone does not suffice to produce the same feeling of health and cleanliness as that achieved by the classic use of soap and water.

3

Unusual or Abnormal Effects of Soap on the "Normal" Skin

MARION B. SULZBERGER, M.D.
and
RUDOLF L. BAER, M.D.

A number of different circumstances may bring about abnormal effects of soaps on the "normal" skin. Probably the most common of these circumstances are: too frequent washing with soap and water and/or excessively long exposures to soap and water. Many surgeons, physicians, dentists, bartenders, housewives, laundresses, dishwashers, and certain industrial workers are inevitably subjected to such inordinate exposures in their daily routines.

Excessive exposures to soap and water remove the protective covering mantle of the skin and temporarily prevent a reestablishment of this mantle and of its normal acidity. In this manner, soap leads to a "degreasing" of those parts of the human skin which are covered with sebaceous material. Children and older persons usually tolerate the degreasing action relatively poorly; while adolescents and many persons in the ages of sexual maturity tend to "greasy" skins—which not only tolerate, but actually require considerable and regular removal of fats and oils.

Any excessive removal of the normal covering mantle lays the cells of the horny layer, and eventually the living tissues beneath, open to the direct action of soap, and thus notably to the action of the alkalis and fatty acids present in the soap solution.

The different fatty acids appear to vary in their "primary scrubbing with soap and hot water often makes the individual look and feel better. The ablutions actually do remove the horny plugs, the sebum and the dirt from follicle openings and pores, and remove the detritus from the surface; and do perhaps, in these ways, promote the functions of excretion and secretion by the skin glands and the functioning of other skin cells. But whether or not these effects be as direct and simple as just expressed, no one will challenge the statement that the man, woman, or child who steps from the shower or hot bath, after the liberal use of soap-suds and thorough rinsing, not only presents a more esthetic and healthy picture, but actually feels better. Those who have been deprived, for one reason or another, of the use of soap for days or weeks or months, will testify that this deprivation constitutes a significant cause of discomfort and produces a very real reduction in the sense of well-being. The use of water alone does not suffice to produce the same feeling of health and cleanliness as that achieved by the classic use of soap and water.

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The different fatty acids appear to vary in their "primary irritant" properties; furthermore, the pH at which the fatty acids are used on the skin influences the degree of their irritancy. Blank performed patch tests with undiluted fatty acids and with mixtures of undiluted fatty acids; and found that fatty acids with a low molecular weight (caproic, caprylic, and capric) were more irritating than those with a higher molecular weight (stearic, oleic, and palmitic). Coconut oil contains a large percentage of fatty acids with a low molecular weight, and Blank states that this accounts for the relatively high irritancy of coconut oil soaps on the skin. On the other hand, castor oil contains mostly hydroxy fatty acids and high molecular-weight fatty acids, to which fact Blank attributes the almost complete absence of skin irritation from castor-oil soaps.

According to Blank, the irritancy of fatty acids is the higher the more alkaline the reaction at the skin surface. Thus, he says a fatty acid which is entirely non-irritating to the average human skin at a pH of 3 to 5 may be strongly irritating at a pH of 8 to 9. However, at a pH of 8 to 9 the fatty acid is present in the form of soap or acid salt. Since all soaps cause a more or less temporary shift of the reaction on the skin surface from acid to alkaline, they may tend to increase the irritating action of the fatty acids.

HARMFUL EFFECTS OF ALKALI

The alkali present in soaps includes free alkali, alkali liberated by hydrolysis, and alkali derived from builders and fillers. Under conditions of abnormal exposure, these alkalis eventually bring about marked swelling of the cells of the horny layer, which may finally lead to scaling and dryness of the skin and to more serious inflammation.

Hansen demonstrated in pertinent experiments that powdered keratin undergoes a considerably greater increase of volume in soap solution than in water. He points out that this swelling of the horny layer of the skin may well lead to

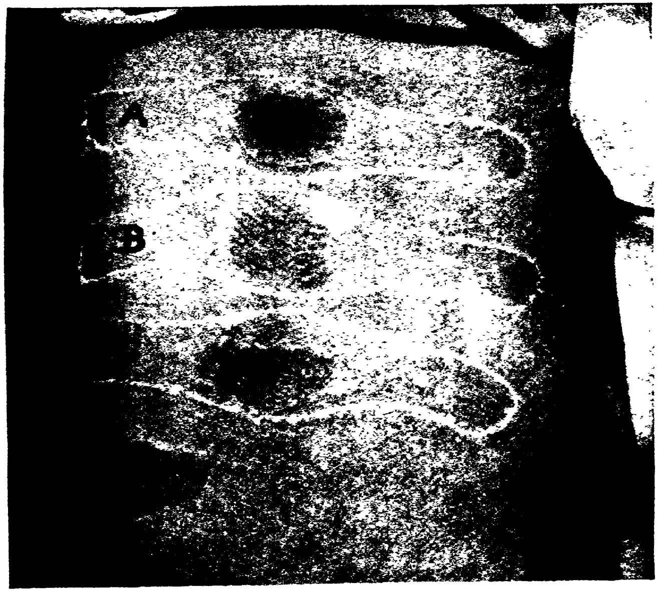

FIG. 15. Results of patch tests with various concentrations of a commonly used toilet soap (read at 48 hours).

A. 5 per cent soap in water
B. 20 per cent soap in water
C. 50 per cent soap in water

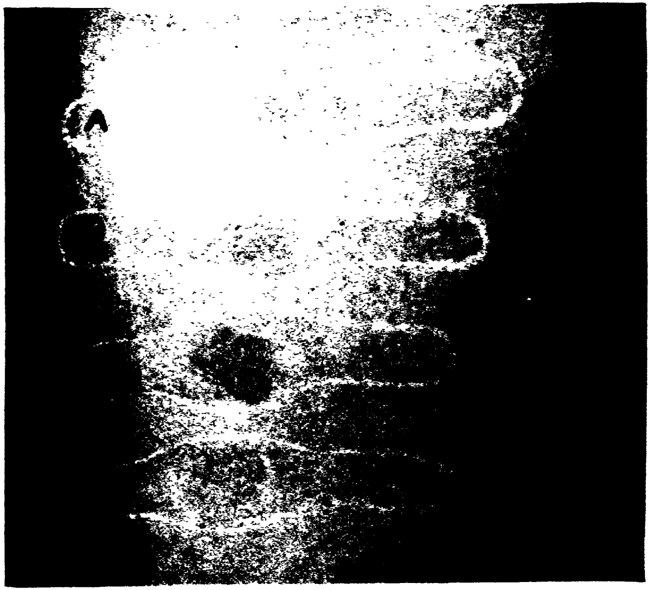

FIG. 16. Results of patch tests with various concentrations of a commonly used toilet soap (read at 48 hours).

A. 5 per cent soap in water
B. 20 per cent soap in water
C. 50 per cent soap in water
D. Soap shavings *without* water

Note that reaction to soap 50 per cent in water is much stronger than to undiluted soap.

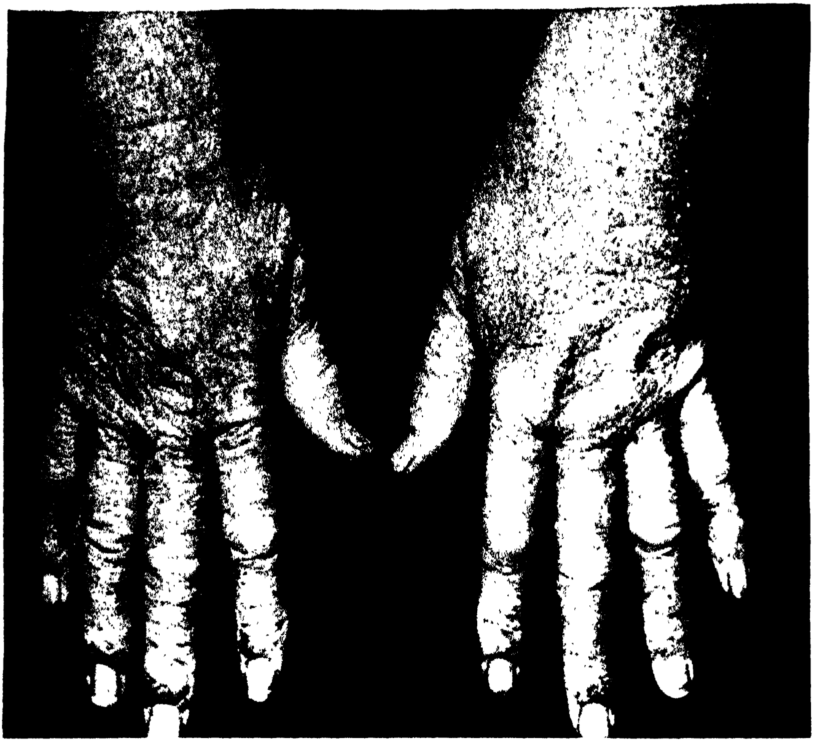

FIG. 17. Chronic dermatitis in a housewife, intolerant to soap and water. (Courtesy of Skin and Cancer Unit, N. Y. Post-graduate Medical School and Hospital.)

increased penetration by water-soluble materials, particularly of water-soluble allergens.

Those skin areas which have a particularly thick horny layer, such as the palms and soles, appear to be relatively resistant to the drying action of soap, despite the fact that they do not possess the sebaceous part of the cutaneous covering mantle. However, this resistance to soap action is absent when the normal status and continuity of the horny layer are impaired by pathologic processes, such as eczematous and other inflammatory changes. (See Chapter 4.)

On a par with the "degreasing" action, a second important abnormal effect of excessive exposure to soap is the impairment of the **alkali-neutralizing** capacity of the skin. The understanding of this mechanism has been greatly increased by studies undertaken by Burckhardt, who investigated the effects of exposure of the skin to alkalis in general. These studies have proved to be of particular importance to the subject of abnormal effects of soaps.

Many of the cases of alkali damage which Burckhardt studied were cases of "soap and water dermatitis" in housewives, laundresses, nickel platers, etc. By repeatedly exposing small areas of skin to successive droplets of alkaline solutions in the presence of indicators, Burckhardt was able to show that normal skin possessed a definite capacity for neutralizing alkali; and that this capacity was a local function and could be exhausted or diminished by repeated exposures at short intervals. Burckhardt believes that the neutralization is accomplished by the CO_2 which is given off by the epidermal cells themselves, and that this capacity is not influenced to any important degree by the secretions of the sweat or the sebaceous glands or by the thickness of the horny layer. Other investigators question this conclusion as to the effects of sweat. In a series of painstaking experiments, Burckhardt found that cases of soap dermatitis consistently evidenced an impairment of the alkali-neutralizing capacity of the skin, as manifested by the fact that the skin either neutralized the standard alkali solutions more slowly, or by the fact that on repeated exposure the skin's capacity to neutralize was more quickly exhausted, or both. Regardless of whether the impaired alkali-neutralizing capacity demonstrated was the result or the cause of the dermatitis from soap and water, Burckhardt's experiments certainly seem to support the theory that, when soap damages the skin, it is largely because of the alkali effect.

Therefore, the alkali effects plus the fatty-acid effects, together with the detergent and removal effects, are to be generally regarded as the principal mechanisms by which excessive exposure to soap can damage the normal skin. However, Jordon and associates have published findings which, they believe, contradict this concept. These authors are of the opinion that the eczematizing action of soap is mainly attributable to allergic sensitization to certain ingredients of the soap solution, i.e., to the fatty acids or to one or more of the many miscellaneous ingredients of soap. The evidence submitted by Jordon et al. shows that both among "normal" persons and, to a greater degree, among eczema patients, there are certain individuals who are hypersensitive to soaps. While no investigator today doubts the existence of such a thing as hypersensitivity to soap, there is as yet little or no evidence that this hypersensitivity to soap, to its fatty acids or other ingredients, is generally an allergic one, i.e., a state generally based on a specific immunologic sensitization mechanism. On the contrary, it appears that in the large majority of instances the soap damage is not attributable to allergic sensitization. Nevertheless, in a few exceptional cases, specific contact-type allergic sensitivity to the perfumes, dyes, fillers, fats, fatty acids, and other ingredients can be demonstrated. In these cases, a true allergic contact-type eczematous dermatitis can ensue following even a single exposure to the soap. This type of allergic sensitivity appears to be extremely rare, when one considers the low incidence of such cases in the light of the fact that soaps are used daily by millions of people. On the other hand, it is to be stressed that even mild cutaneous damage due to soaps may favor allergic sensitization and reactions to other allergens, since such damage involves the removal of parts of the protective covering mantle and thus increases the permeability of the horny layer. Similarly, soap effects may be added to, or may aggravate, the effects of other irritants or pathogenic agents, and thus act as predisposing, potentiating or trigger factors in many cutaneous disease processes.

> The demonstration of true allergic sensitivity to an ingredient of a soap is rendered difficult, if not impossible, by the fact that the application of soap solutions in skin tests invariably includes, not only the application of the potential allergenic ingredients, but also application of dissociated alkali and acid as well. Thus, when skin testing, one is obliged to include the direct effects of alkalis and acids on the skin, in addition to the effects of the possibly allergenic dyes, perfumes, fillers, fatty acids, fats, etc.
>
> It is therefore doubtful whether patch tests with soap solutions are adequate for proving or excluding the existence of allergic contact-type sensitivity to an ingredient of the soap. In this connection, it must be recalled that the patch test has been well standardized only for the study of allergic contact-type hypersensitivity; and that its great clinical usefulness in allergic eczematous dermatitis is due mainly to this standardization and to our knowledge of the limitations of its uses. On the other hand, the orthodox patch test, or even the modified skin tests of Emery and Edwards or of Kooyman and Snyder, have not yet been sufficiently investigated in relation to the study of primary irritant effects, of acid and alkali effects, etc., or for the study of relatively complicated mixtures such as soap solutions.

CLINICAL ASPECTS OF ABNORMAL EFFECTS OF SOAP ON THE NORMAL SKIN

The cutaneous changes due to abnormal soap effects may manifest themselves in many different clinical pictures.

This can be attributed, in part, to the difference between the skins of different individuals. Moreover, soap effect is frequently only one of two or more factors which, through addition, cumulation, or synergism, eventually produce a particular clinical dermatosis. Other factors which are frequently associated with soap in bringing on cutaneous damage are the predisposing local and systemic influences, as well as the influences of other exogenous agents (chemical agents, physical agents—cold, mechanical trauma, etc.—actinic effects, the action of inanimate allergens or of living bacteria, virus, fungi, etc.).

DIRECT MANIFESTATIONS OF SOAP DAMAGE

Despite this diversity of clinical pictures in which soap effects may play a greater or lesser role, it may nevertheless be said that the cardinal features of chronic cutaneous soap damage are usually *dryness, scaling, redness,* and eventually *fissuring.* The picture closely resembles that which is commonly known as "chapping." In addition to these more direct and simple effects, there is a group of dermatoses in which it is impossible to ascertain just what part of the clinical picture is attributable to soap effects and what part to other causes. Yet, in some of these cases, soap effects appear to be of decisive importance.

"WINTER DERMATITIS" OR "WINTER ECZEMA"

Thus, in certain individuals and under certain circumstances, *vesicular eczematous* eruptions appear on the basis of the dryness and redness which follows excessive exposures to soap and water. Typical of these eruptions are the so-called "winter eczemas," which consist of round or oval, larger or smaller, vesicular or crusted, oozing patches with a tendency to central healing. These eruptions are most commonly localized on the dorsa of the hands, on the forearms, and on the extensor surfaces of the lower legs. They usually occur and recur with the onset of cold weather; and are particularly liable to be persistent in older, "super-cleanly" individuals who, in addition to regular washing with soap and water, take one or two or more hot baths daily. Many "nervous" or "overtired" men and women, who resort to the tub as a sedative or stimulant, will succeed, by dint of much washing and immersion, in producing a "bath itch" and a "bath eczema."

The localization of these eruptions on the dorsa of the hands may be due to the fact that the hands are almost always more exposed to soap and water than any other part of the body, but it is doubtful whether this is the complete explanation. The localization on the lower legs is even more difficult to explain. It may be due to the fact that the circulatory apparatus of the legs is often a particularly vulnerable part of the vascular system. Particularly in older persons in whom an involutional dryness and thinning of the skin is often associated with poor circulation, it is quite comprehensible that the legs would be the sites most susceptible to the combined effects of soap, water and cold weather. Furthermore, there is good reason to believe that rinsing and drying after bathing are often less carefully performed on the legs than on other body areas.

"HOUSEWIFE'S ECZEMA"

Another dermatosis in which soap effects may eventually lead to vesiculation is the so-called "housewife's eczema." This type of eruption occurs principally on and between the fingers and on the dorsa of the hands of women who do housework and laundry work, entailing more or less regular and prolonged exposure to dishwater and/or to strong and alkali-rich soaps, including scouring soaps, laundry soaps, and household soaps. However, "housewife's eczema" also affects those who are not housewives, but whose profession or other activities involve exposures similar to those suffered by housewives (surgeons, other physicians, dentists, soda clerks, barmen, dishwashers, kitchen workers, canners, and people employed in other occupations necessitating frequent immersion and cleansing). The eruption in "housewife's eczema" usually begins with mild dryness, redness, and scaling, which, as the condition becomes more severe under continued exposure to soap and water, leads to fissuring and crusting, and eventually to vesiculation, and ultimately to thickening and lichenification.

Abnormal effects produced by too much soap and water include the heightening or creation of susceptibility to certain types of skin infection. Some of the infectious agents concerned, e.g., certain fungi, cocci and viruses, are practically ubiquitous and constitute the usual flora of so-called normal skin. For this reason, when excessive exposures to soap and water lead to infectious processes in which these *ubiquitous facultative pathogenic agents* are concerned, these infections are to be regarded as being to a certain degree within the category of the abnormal effects of soap and water on essentially normal skin. We therefore include a partial discussion of these infections in the present chapter, and also give additional details in the following chapter.

"Housewife's eczema" and other occupational eczemas of this type are commonly associated with infectious paronychias, nail changes, and interdigital erosions.

In the paronychias, it is likely that the staphylococci and/or fungi invade the periungual tissue which has been "softened up" for the invasion by the action of the soap and water.

In the interdigital erosions, the secondary invaders are usually fungi, notably monilias.

Many other forms of fungous infection may follow the "softening up" action of too much moisture and maceration, such as can be produced by excessive immersion in soap and water. It is not difficult to explain why fungi are particularly prone to invade the superficial tissues in soap-damaged areas. The most common fungi—the epidermophytons, trichophytons, monilias, etc.—are known to propagate only in dead tissue; and, as has been previously mentioned, the soap-damaged areas present unusually large quantities of such dead tissue and therefore offer fertile soil, in the form of damaged and swollen horny material, as well as conditions of warmth and moisture favorable to the propagation of these fungi.

The fact that areas which have been damaged by too much soap and water are unusually susceptible to infection by bacteria, especially by staphylococci, is thought to be due mainly to two factors:

1. The creation of portals of entry for the bacteria through the fissures and cracks caused by the excessive use of soap; and
2. A general lowering of resistance to bacterial infection due to the removal of the antibacterial "acid mantle" of the skin. The displacement of the normal "acid mantle" by an abnormally alkaline mantle, as a factor favoring bacterial invasion of the skin, has been stressed by many authors; and is generally accepted as the most adequate explanation of the manner in which abnormal exposures to soap can predispose to skin infections.

In many of the cutaneous pictures described, it is impossible to determine just what proportion of the combined effect is due to too much soap and water, and just what proportion is due to other added or pre-existing factors.

4

The Effects of Soap on the Abnormal or Diseased Skin

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and
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The effects of soap and water may be either indifferent, distinctly beneficial, or decidedly harmful to the diseased skin. For this reason, the decision as to whether washing with soap and water is to be permitted can be properly made only by the experienced physician after careful consideration of the particular case. To this end, the physician should be in possession of all available information concerning the various types of dermatoses and the types of cases in which the use of soap is indicated or contraindicated.

In general, the same factors which contribute to the tolerance or intolerance of the normal skin obtain in regard to the toleration of soap and water by the diseased skin. These factors have been described in the preceding chapters and include the alkalis, fatty acids, and adjuvant materials which may be present in the soap, the frequency and duration of the exposures, the quality of the water used, the mechanical measures employed, the amount of rinsing performed, and other circumstances.

Soap and water serve to excellent purpose in a great number of dermatoses, not only as ordinary cleansing measures, but also to remove the substances which result from the pathologic processes (scales, crusts, sebum, secretions, etc.) and/or the undesirable remains of the local remedies employed.

However, in all skin diseases the cleansing measures to be used must be selected and prescribed by the physician with the same care and attention to detail as are necessary in selecting and prescribing the other forms of treatment. General practitioners and even dermatologists often pay too little attention to the cleansing methods the patient employs. Yet the results obtained are often dependent upon the proper choice and the correct use of cleansing methods.

SOAP AND WATER AS THERAPEUTIC AGENTS

While soap and water are unquestionably harmful in certain skin diseases, it is not only the cleanser of choice in many other dermatoses, but also serves as a most *valuable therapeutic agent.*

As a rule, those dermatoses which are due to, or associated with, excessive production of sebaceous material (excessive oiliness, greasiness, etc.—"kerose" of Darier) will be benefited by washing with soap and hot water. The same is true of dermatoses manifesting horny and/or greasy plugs, with or without the subsequent formation of papules and pustules (keratosis follicularis, acneform eruptions, etc.).

However, even when indicated, soap and water are rarely to be used by themselves; and are generally best prescribed in conjunction with other indicated forms of local and systemic treatment.

Even in those cutaneous diseases in which soap and water usually constitute a most effective part of local treatment, individual cases will be encountered in which this treatment is not tolerated. In cases of this kind, the use of soap and water must often be abandoned despite its known beneficial effects in the general run of similar dermatoses. Thus, while soap is good for most cases of acne vulgaris and seborrhea, not all of these will tolerate soap and water—just as mercurials will not be tolerated by each and every case of impetigo, and tars will not be tolerated by every case of eczema.

In all dermatoses accompanied by significant degrees of scaling, redness, oozing, swelling, or other signs of diffuse or acute inflammation, there is an increased likelihood that irritation from soap and water will occur. In these skin conditions, therefore, soap and water should be employed only under rigid control and observation.

I. DERMATOSES IN WHICH SOAP AND WATER SHOULD GENERALLY BE USED

A. Dermatoses Associated with Increased Activity of the Sebaceous Glands (Grease-Solvent Action of Soap)

1. **Acne Vulgaris** (including comedo- or "blackhead"-acne and cystic and conglobated forms). Acne vulgaris is characteristically a disease of puberty and adolescence. During these periods of life the functions of the sex glands awaken and stimuli are sent forth which greatly increase and often somewhat disturb the activities of the skin glands. Moreover, as is notorious, the youthful adolescent is not commonly addicted to particularly diligent and painstaking use of soap and hot water. The prescription for regular and liberal soap and hot water scrubbings will, therefore, often introduce an innovation and will frequently produce a striking change for the better in cases of adolescent acne. Three or more scrubbings daily, with a rough cloth or soft complexion brush, should be employed and are usually remarkably well tolerated by the acne patient.

The repeated soap and water scrubbings remove the excess sebum and horny material on the surface and thus improve the appearance of the skin. At the same time, the formation of plugs at the openings of the hyperactive sebaceous glands—which is one of the fundamental factors bringing about the development of acne blackheads, papules, pustules and cysts—is either prevented or lessened. The beneficial effects of soap and water in acne may be attributed: (a) to the keratolytic action of the soap solution, which softens and/or removes the horny material in and around the follicle openings; and (b) to the degreasing action, which removes the sebaceous material which has become inspissated in these openings.

Another factor which may be contributory to the beneficial action is the removal of microorganisms residing in the sebaceous and horny material. (See Chapter 2.) The exact role of these microorganisms in acne vulgaris is not known; but many investigators believe that bacteria may contribute, in some way, to the formation of inflammatory papules and pustules.

Soaps medicated with an anti-seborrheic agent, such as sulphur, are sometimes of particular benefit in acne vulgaris. But, on theoretical grounds at any rate, superfatted soaps are usually contraindicated, since the added fat would, if anything, tend to reduce the desired "degreasing" effects.

2. **Acnes of External Causation** (oil acne, acnes due to chlorinated compounds (Halowax, etc.), to waxes, pitch, tars, etc.). In these conditions, the fundamental pathologic change is generally accepted as being the plugging of follicles and gland-orifices by exogenous materials. Frequent applications of soap and hot water, as well as the use of other detergents and the maintenance of general cleanliness of clothes, work rooms and person, are often helpful both in treatment and prevention.

3. **Acneform Drug Eruptions** (e.g., due to bromides and iodides). Indications are essentially the same as in acne vulgaris. However, there is usually less excess sebum and less tenacious plugging of the follicles than in acne vulgaris. Therefore, frequently-repeated vigorous scrubbings are usually not as necessary and occasionally not as well tolerated as in acne vulgaris.

4. **Acne Rosacea.** The indications for soap and water are essentially the same as in acne vulgaris and in acneform drug eruptions. Soaps medicated with sulphur may be useful. Acne rosacea not too uncommonly tends to become irritated when soap and water is used to excess.

5. Seborrhea and Seborrheic Dermatitis. Particularly, if not exclusively, in those cases in which the greasiness and scaliness dominate the picture, soap and water constitute a useful adjuvant to therapy. Two or three washings daily may be recommended. However, in those cases in which redness and other inflammatory elements dominate, there may well be an intolerance to soap and water.

6. Seborrhea Sicca and Oleosa of the Scalp (Pityriasis Capitis—Dandruff). Soap and water, either in simple form or in shampoos, lotions, etc., are an effective palliative agent.

The excess scales and oiliness are removed by shampoos and thorough rinsing, one or twice weekly, or even more frequently. The addition of medicaments, such as tar, sulphur, mercurials, etc., to shampoo mixtures is often of decided value.

However, here again soap and water may occasionally irritate the scalp condition. In some cases, other forms of detergents are superior to soap in their therapeutic effects (wetting agents, sulfonated oils, lecithin and other emulsifying agents, etc.).

B. Dermatoses Associated with Bacterial and Other Infections (Germicidal Action of Soap)

In these conditions, soap and water is used, not primarily with the aim of "curing" the presenting dermatosis, but principally to prevent the spread and recurrence of infection.

1. Impetigo. Regular washings of the affected parts as well as of the surrounding areas with soap and water are frequently of great value; indeed, this procedure alone may frequently be curative. Care should be taken to make certain that the unaffected areas are washed **before** the affected areas; and, in turn, dried **before** the affected areas are dried. Whenever possible, it is preferable to use a separate washcloth and separate towel for affected and for unaffected areas. In impetigo, the hands should, of course, be kept away from the infected sites; furthermore, they should be washed with soap and water after each application of therapeutic agents and after any other suspected contact with the lesions.

2. Furunculosis, Carbuncles, Folliculitis, Paronychias, etc. In these infectious processes, the indications are similar to those in impetigo; and the correct use of soap and water can, in itself, be a powerful influence in preventing dissemination or recurrences. Moreover, in addition to its antiseptic action, the use of soap is indicated because of its softening action on the horny layer, which facilitates a further "coming to a head" and "opening" of the above-mentioned pyodermic lesions. This softening action has often been expedited through the use of liquid soaps (potassium soaps), liquid soap poultices, or soap plasters.

In paronychias, a combined softening, antiphlogistic, and bactericidal action is achieved by soaking the affected member in solutions of soap in hot water.

Even the slightest irritation due to soap must be assiduously avoided in pyodermas, since any form of damage or any marked drying action may lead to the production of superficial cutaneous defects which may serve as portals of entry for the microorganisms to invade previously unaffected tissues. Furthermore, excessive use of soap may lead to an impairment of the "acid mantle" that is generally accepted as being important in the protection of the skin against pathogenic microorganisms (Chapters 2 and 3).

Soaps containing antiseptic agents, such as mercury, may be useful in pyogenic dermatoses. They help to destroy and remove the disseminated microorganisms which often take up their abode on the skin and which will, unless eliminated, tend to produce new lesions.

C. Dermatoses Associated with Hyperkeratosis (Excessive Horn Formation)—(Macerating and Keratolytic Action of Soap)

Mention has already been made of the horn-softening and macerating effects of soap and water in acnes, furuncles, etc.

These effects are particularly desirable in dermatoses associated with abnormal thickness of the horny layer or with a profusion of heaped-up scales; and are also employed in skin diseases in which there is no abnormality in the thickness of the horny layer, but in which it is desirable to soften up the normal horny layer.

1. **Callosities (Callus), Clavus (Corns), Palmar and Plantar Hyperkeratoses (Including Keratoderma Climactericum and Mal de Meleda).** In these dermatoses, prolonged exposure to soap solutions and emulsions (e.g., soap "baths") brings about a softening of the horny material which, in turn, facilitates subsequent mechanical removal and makes for increased penetration by subsequently applied local remedies.

2. **Affections of the Nails.** In various diseases or abnormalities of the nails, soaking in soap solutions is valuable in that it facilitates the removal of excessive or diseased nail tissue. This procedure is the familiar one employed by manicurists, chiropodists, etc. As mentioned above, soaking the member in a hot soap solution is an excellent measure in treating ordinary incipient paronychias.

3. **Keratosis Follicularis (Darier's Disease).** The heaped-up horny material, which is seen in many of these cases, can often be most readily removed through soaking or washing with soap solutions.

4. **Follicular Keratoses in Lichen Pilaris, Lichen Spinulosus, Follicular Keratoses in Dysvitaminoses, etc.** The follicular horny plugs in these conditions can usually be removed and the condition kept under control by frequent scrubbing with a brush and soap and hot water.

5. **Psoriasis.** Scrubbing with soap and water is particularly valuable in those forms of the disease which are associated with a marked heaping-up of scales. A thorough scrubbing of the lesions with soap and water and a fairly stiff brush should be carried out before each application of the local remedies. This procedure removes the scales which have accumulated over the actual site of the active psoriatic

process and thus permits the antipsoriatic agents to penetrate more effectively.

6. Scabies. Soap and water softens up the horny material overlying the burrows and exposes the mites more directly to the action of antiscabetic agents, such as benzyl benzoate, sulphur, balsam of peru, etc. Many benzyl benzoate emulsions contain as much as 33⅓% soft soap, which is embodied in the vehicle to promote the softening process.

D. DERMATOSES IN WHICH SOAPS ARE INDICATED BECAUSE THEY REMOVE UNESTHETIC PRODUCTS FROM AN OTHERWISE NORMAL SKIN

1. Hyperidrosis (Excessive Sweating), Bromidrosis (Malodorous Sweating), Chromidrosis (Stained or Colored Sweat). In these dermatoses, frequent washing of the affected areas with soap and water tends to remove the undesirable materials and to counteract the unsightly appearance or unpleasant odors. The regular and frequent use of soap and water may also produce a transitory reduction in the quantity of the abnormal materials produced, by bringing about a mild swelling of the horny layer and a consequent constriction of the opening of the sweat ducts. Moreover, since microorganisms present on the skin surface seem to play a contributory role in the production of some cases of chromidrosis and bromidrosis, the antiseptic properties of soap may be helpful in the elimination of these microorganisms. Highly scented soaps can be used in bromidrosis in an attempt to cover up the fetid odor.

II. DERMATOSES IN WHICH SOAP AND WATER ARE GENERALLY CONTRAINDICATED

On the basis of previous statements, it is obvious that the use of soap and water should be reduced or eliminated in those dermatoses which, in and of themselves, present features which are known to occur as the result of excessive use of soap (dermatoses associated with an inadequate supply or total lack of sebaceous material, abnormal dryness, fissuring, rise in the pH of the cutaneous surface, etc.). However, aside from such dermatoses, there are several skin conditions in which clinical empiricism, rather than logical consideration, has led to the conclusion that the use of soap is contraindicated.

A. SOME DERMATOSES ASSOCIATED WITH EXCESSIVE "DRYNESS" OF THE SKIN

In these dermatoses soap and water commonly leads to an increase in the dryness of the skin. As the dryness becomes more pronounced, the tendency to the formation of fissures increases; and this, in turn, contributes to an increase in alkalinity. (In their studies on the pH of the skin surface, Bernstein and Herrmann found the highest degree of alkalinity in the fissures present in eczematous processes.)

Thus the continued or repeated use of soap as a cleansing agent on excessively dry skin is likely to lead to a vicious circle. The soap creates an increase in dryness and alkalinity, which leads to fissuring and exudation; and these, in turn, lead both to increased alkalinity and to the necessity for further "cleansing."

The following conditions, all of which are characterized by dry skin, constitute a group of dermatoses in which the use of soap and water should usually be omitted or reduced to a minimum:

1. **Congenital abnormalities**—e.g., ichthyosis. Soaps are usually contraindicated in the mild forms of ichthyosis in which there is excessive dryness but no thick accumulation of horny material. But in areas with marked thickening of the horny layer, soap may be useful because of its previously described softening and keratolytic effect.

2. **Dysvitaminoses of the skin**—e.g., the "dryness" (xerosis) present in typical cases of dysvitaminosis of Vitamin A, Vitamin B complex and perhaps Vitamin C. In these con-

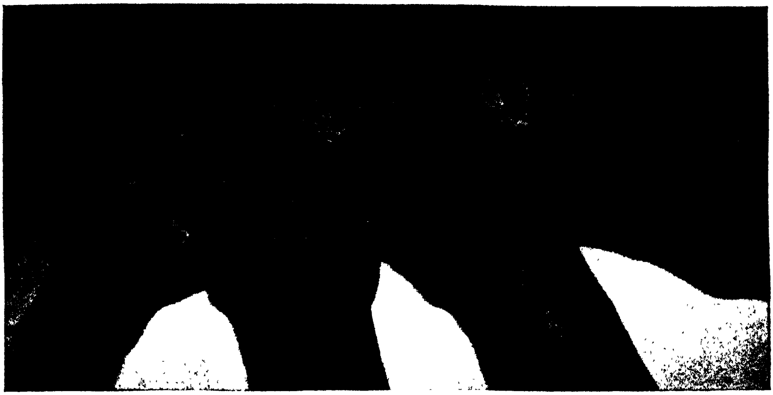

FIG. 18. Interdigital erosion in a housewife. These cases while due to yeast (monilia) infections cannot tolerate soap and water or other cleansers, and are commonly made worse by exposures incident to housework. (Courtesy of Skin and Cancer Unit, N. Y. Postgraduate Medical School and Hospital.)

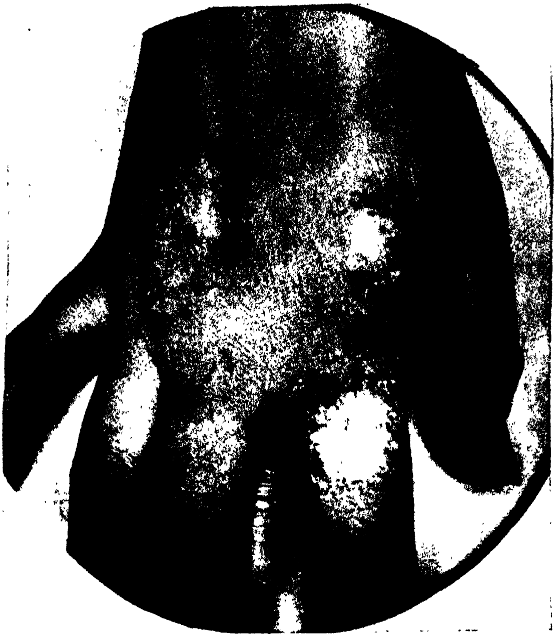

FIG. 19. Nummular eczema, a form of eczematous dermatitis which is almost invariably made worse by soap and water.

ditions, the contraindications to soap and water are similar to those described under congenital abnormalities.

3. **Endocrine dysfunctions**—e.g., the xerosis present in hypothyroidism and in the involutional or senile dry skin (including pruritus senilis). Here, too, similar contraindications to the use of soap obtain.

4. **Dry skin as a sequela to the effects of physical agents**—e.g., late radiodermatitis, phrynoderma—farmer's and sailor's skin. In these conditions, tolerance to soap and water is also likely to be reduced.

5. **Dry skin resulting from alkali damage,** conditioned either by inherent susceptibility to this damage or by excessive exposure to alkalis in soap solutions, or as encountered in occupation and industry—e.g., physicians, nurses, concrete workers, nickel platers, leather tanning workers, housewives, laundresses, etc.; or by a combination of these factors.

In all these conditions, whenever intolerance is present, soap and water should be entirely interdicted for long periods of time. Sometimes the skin will recover from its susceptibility to alkali damage when soap and alkalis are eliminated for several weeks to months; and sometimes intolerance to soap persists despite such protracted avoidance.

When ordinary soaps are not well tolerated, the possible use of other cleansing measures must be given consideration; and here the new detergents and soap substitutes will undoubtedly achieve a great sphere of usefulness.

Some observers believe that superfatted soaps present an advantage and may be substituted for ordinary toilet soaps in mild cases of soap intolerance. Sharlit, for example, recently described a series of cases in which he found a particular superfatted soap to be less drying than ordinary toilet soaps.

As a rule, however, it will be necessary to supply the patient, who is intolerant to soap, with some form of non-alkaline substitute. But many sulfated (sulfonated) oils and other non-alkaline detergents still have too much of a drying effect.

Intolerance to soap is frequently increased by too many baths or showers which, in themselves, produce dryness of the skin in some individuals. Furthermore, intolerance to soap is usually much more marked in cold weather, when there is a relative lack of perspiration and evaporation, plus a reduction in quantity of sebum, and consequently a relative rise in the pH of the skin's surface.

B. Some Dermatoses Due to Infectious Agents

In our discussion of the infectious dermatoses in which the use of soap and water is usually an effective therapeutic agent, we mentioned that individual cases of intolerance are encountered even in these conditions; and that the slightest irritation caused by soap may lead to exacerbation and spread. (See page 65.)

There is still another group of infectious skin diseases in which soap and water generally is harmful rather than beneficial. In these conditions, the use of soap and water, despite its possible germicidal and cleansing effects, brings about the following undesirable changes:

1. The impairment or abolition of the acid mantle and its protective action. (According to Marchionini, Schade and Hartung have reported that hemolytic streptococci and pneumococci are susceptible to the germicidal effects of the normal acid mantle; while staphylococci and non-hemolytic streptococci are relatively resistant.)
2. The softening and maceration may produce conditions favorable to the propagation of pathogenic microorganisms. (This holds particularly true in regard to fungi. See pages 58 and 59.)
3. The degreasing and keratolytic effects tend to produce macroscopic or microscopic fissures which present the microorganisms with new portals of entry. (See page 65.)

The following are among the common infections of the skin in which the use of soap and water is likely to prove undesirable:

1. **Fungous infections of the non-hairy skin**—e.g., moniliasis, ringworm of the groins, "athlete's foot," etc. Moisture, maceration, dead horny tissue, and relative alkalinity are the well-known favorites of the fungi causing the above diseases. And, as has been shown, these conditions are the very ones which soap and water tends to produce. Moreover, recent studies of Peck and Rosenfeld indicate that certain constituents of sweat (and of sebum?), notably certain fatty acids, have fungistatic and fungicidal action. The use of soap may, of course, either saponify or remove these beneficial acids. Therefore, on theoretical grounds, soap and water should be bad for most cases of superficial fungous infections. And clinical experience does indeed tend to show that this theory is applicable in many cases, despite the fact that cleanliness is, in general, desirable in combatting infection. On the other hand, the horny substances in which the fungi dwell should be removed; and soap and water can help in this removal, particularly when excess horn-formation or marked scaling and adherent dead tissue are present. Thus, the use of soap and water is a two-edged sword in fungous diseases of the glabrous skin. The circumstances of the particular case, and its responses, must decide as to whether or not and just how soap and water should be employed.

2. **Other Infections.** In many other infections, such as pyodermas, herpes simplex, etc., even the slightest irritation which may be produced by soap tends to favor recurrences, exacerbations, and particularly spread or dissemination of the infection. Therefore, in all such cases, when there is even a minor degree of intolerance, soap and water may make the condition worse instead of better.

There is still another mechanism that may be at the basis of the harmful effects which soap and water occasionally elicits in pyodermas. This mechanism is the removal of the bactericidal substances which Bergeim and Cornbleet found in normal sweat.

3. **Eczematous Dermatoses.** Although Marchionini has shown that there is a shift of the pH of the skin toward the

alkaline side in most vesicular eczemas, the exact manner in which soap and water actually harms the eczematous skin is not known. Nevertheless, it is a most striking fact that such harm does occur in many cases.

Most cases of occupational eczema, "housewife's eczema," contact dermatitis, and nummular eczema, etc., will do better without soap and water, or with very little of it; and in many such cases, complete abstinence from soap and water is required.

4. Atopic Dermatoses. These conditions include most cases of infantile eczema and of lichen simplex disseminatus (disseminated neurodermatitis) and flexural dermatitis or prurigos, in children and adults. In the large majority of these dermatoses, soap and water is poorly tolerated; and in some not tolerated at all.

Many infantile eczemas are notoriously sensitive to alkalis, as are "diaper rashes," etc.; and in some instances the mere avoidance of irritation from the alkaline effects of soap, plus elimination of exposures to alkaline urine, feces, etc., in the case of diaper rashes, produces immediate favorable effects. When the decision is reached to protect against irritation from the alkaline action of soap, the affected areas must be cleansed without the use of soap. Moreover the bedding, clothing, diapers, etc., must be rinsed thoroughly and repeatedly, in order to remove the last traces of soap and other alkaline cleansers. (In some instances, rinsing with boric acid solution or the use of acid dusting powders is helpful.)

Cases of atopic dermatitis, both in children and adults, are not uncommonly intolerant to soap and water. The cause of the intolerance in this group of skin diseases is not known. But the oozing—and therefore probably alkaline—skin of the baby with severe eczema, and the notoriously dry and fissured skin of the older atopic dermatitis patient would seem, on theoretical grounds, to be particularly susceptible to alkali damage. Moreover, the effects of soap and water would be inclined, by virtue of its degreasing and keratolytic action, *to favor the percutaneous penetration of* *environmental allergens.* And atopic patients are, of course, often highly hypersensitive to allergens derived from their environment, including those from their clothing, bedding, etc.

5. Other Dermatoses. On the basis of clinical experience alone, it may be said that the inflamed skin does not tolerate soap and water particularly well. Thus, numerous cases of common inflammatory dermatoses and some cases of rare dermatoses can be benefited by avoiding or reducing the use of soap. As a general rule, it is wise for the physician to prohibit the use of soap and water whenever the skin is highly reddened or when the dermatosis is active or spreading. After a few days of elimination, the ordinary use of soap and water may be resumed under careful observation of its effects.

The discussions in this chapter demonstrate that in many dermatoses soap and water can exert a powerful influence for good or for bad. The physician who is called upon to treat skin diseases must, therefore, be in a position to take full advantage of the beneficial effects, and to avoid the harmful effects of soap and water. To this end he must have a thorough knowledge not only of the effects of soap and water on the diseased skin, but also of the effects and uses of substitute cleansing measures which may be available.

One available method consists of the use of bland, relatively inert greases or oils, such as mineral oil, olive oil, petrolatum, cold creams, etc. This method has long proved invaluable in many cases intolerant to soap and water. However, it is by no means ideal as a cleansing procedure and is certainly in many ways inferior to soap and water. Warm water alone, or preferably with the addition of "demulcents" such as corn starch, bran, oatmeal, etc., may be helpful and soothing, but is certainly not a generally satisfactory method of cleansing.

The urgent need for other forms of non-alkaline cleansers is obvious. The new non-alkaline "soap substitutes" which can be obtained today are of many varieties (Chapter 8). But much further clinical investigation will be necessary before the indications and contraindications for the use of a particular sort of soap substitute can be determined with accuracy in each particular case.

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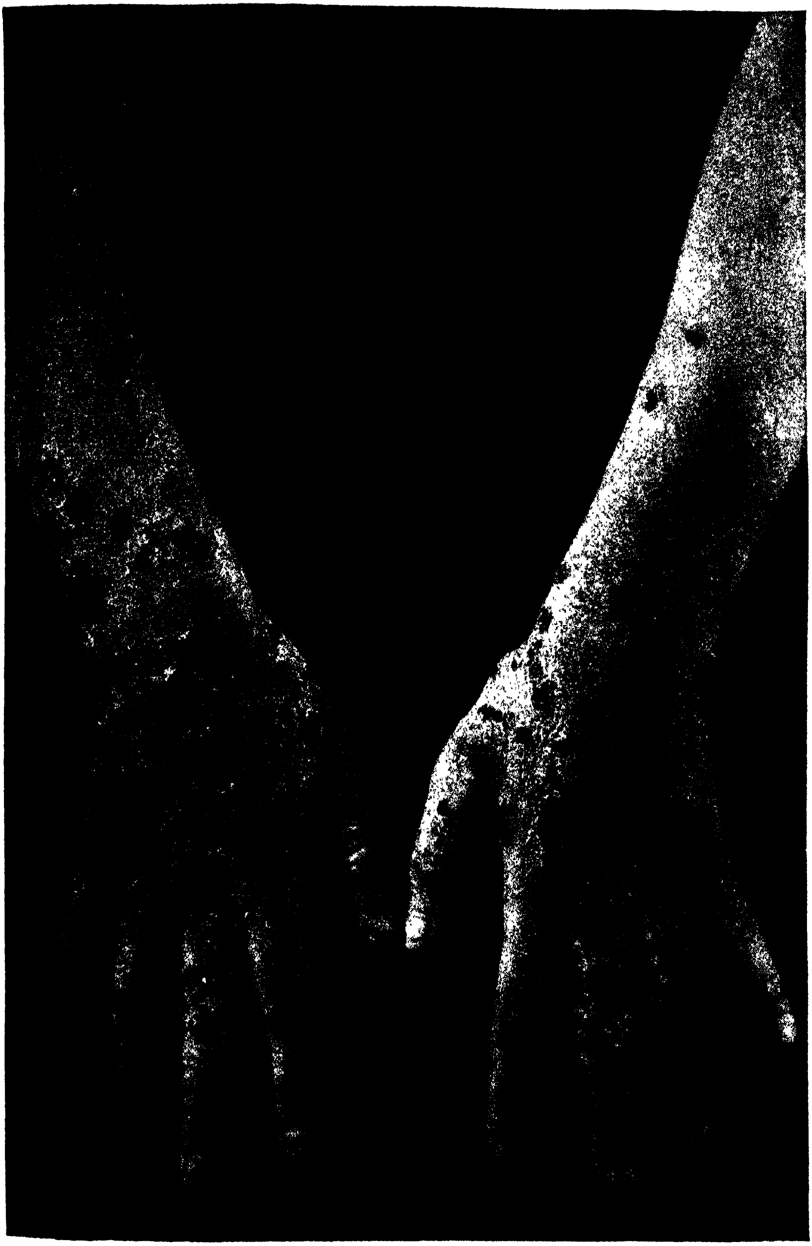

FIG. 20. Nummular eczema. Some cases develop on the basis of dry skin especially in the fall and winter. Soap and water aggravates just as too frequent cleansing may produce a dermatitis in a dry or xerotic skin.

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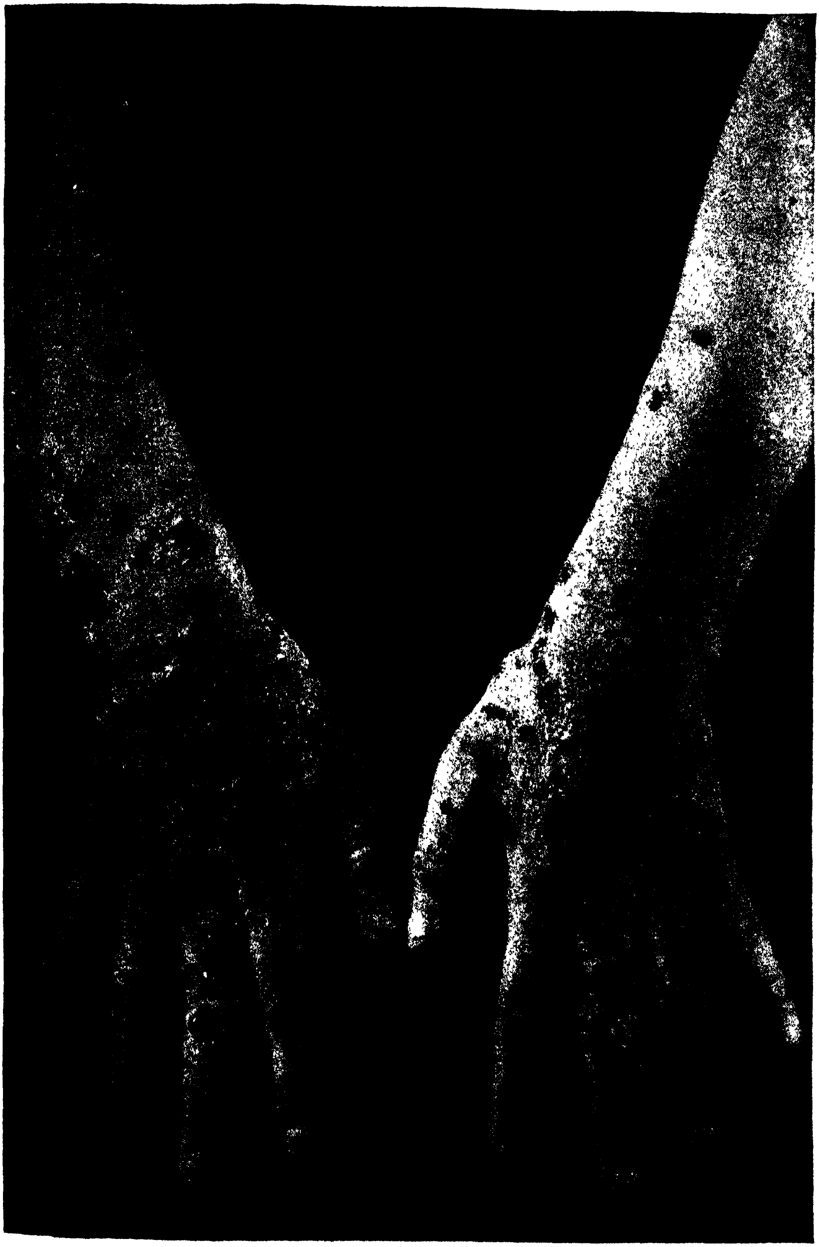

FIG. 20. Nummular eczema. Some cases develop on the basis of dry skin especially in the fall and winter. Soap and water aggravates just as too frequent cleansing may produce a dermatitis in a dry or xerotic skin.

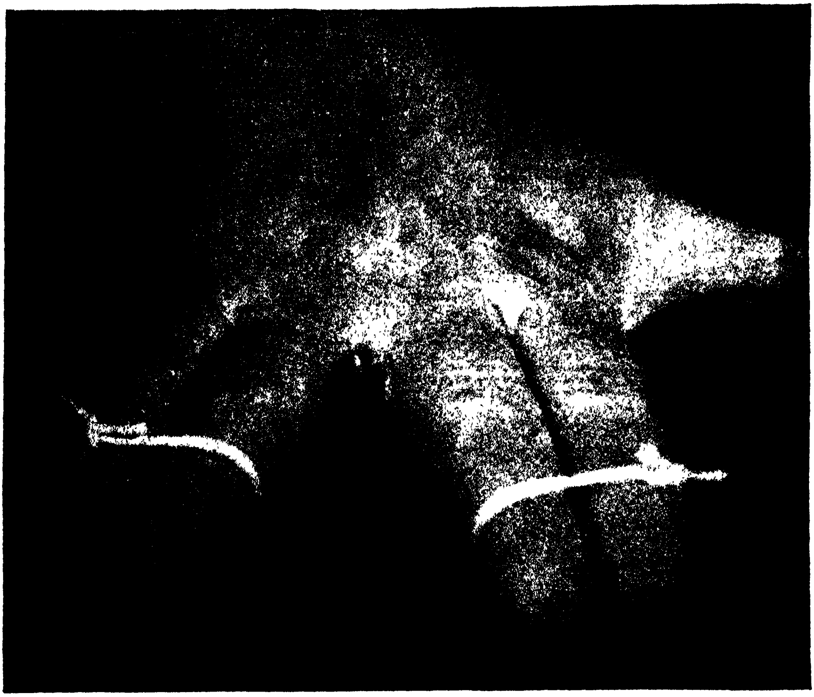

FIG. 21. Erosio interdigitalis saccharomycetica (yeast or monilial infection of the webs of the fingers). Occurs almost only in women and is often associated with other forms of monilial infection, such as perlèche and yeast paronychias. Exposure to soap and water continues this infection and prevents or retards the otherwise quick improvement from antiseptics. One per cent aqueous gentian violet solution, copper sulfate solution, etc., are usually curative if there is little or no contact of the affected parts with soap and water.

FIGS. 22 and 23. Indurated acne. The free use of soap and water should be encouraged in acne. If this produces mild irritation and scaling it is helpful. Scaling tends to lift the horny blockade at the mouth of the follicle and this permits better drainage. The acne blackhead is not accumulated dirt nor evidence of neglect of soap and water.

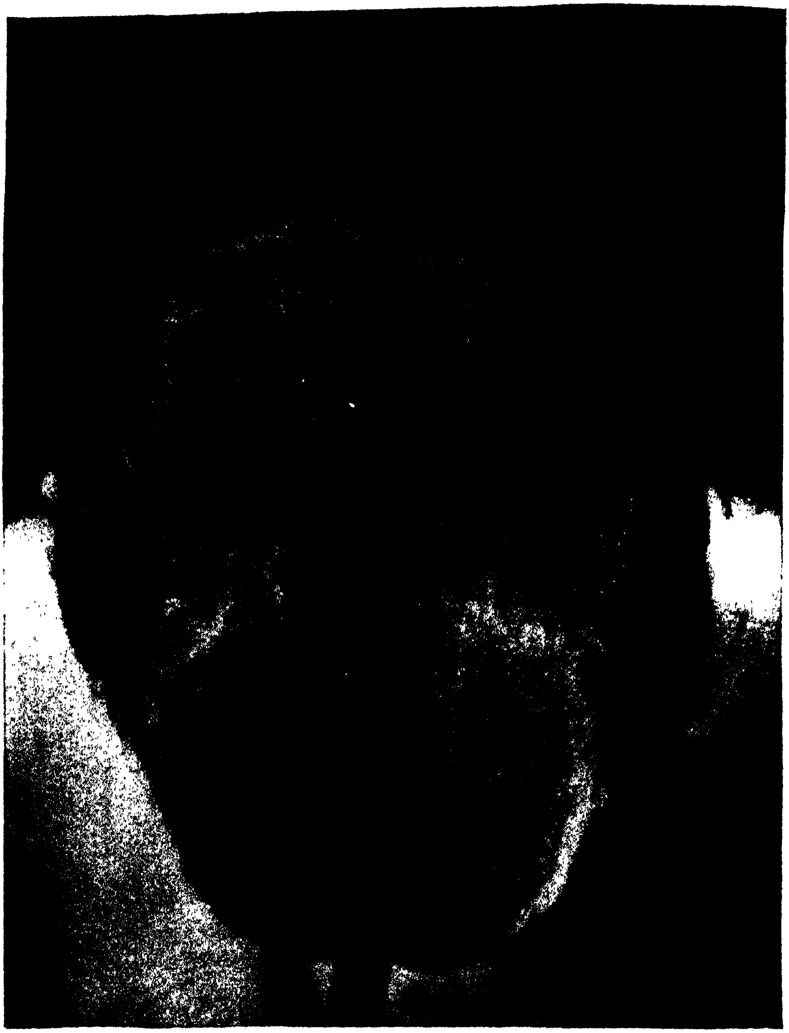

FIG. 21. Seborrheic dermatitis of the scalp. The various stages and degrees of this disease, from the simple scaling of dandruff to those with more pronounced symptoms of dermatitis, are improved by cleansing. Seborrheal itching yields immediately to washing. Shampooing prevents the accumulation of the usually accompanying abundant oil, scale and detritus. Excessive washing, of course, dries and irritates the scalp, though this part will stand far more of this abuse than almost any other part of the skin.

5

The Effects of Soap on the Hair

THEODORE CORNBLEET, PH.D., M.D.

A proper understanding of the effects of soap on the hair depends on a full appreciation of the anatomy and physiology of the hair, reasons for cleansing the hair, and the characteristics of the available cleansing materials. These individual aspects of the question are discussed in some detail in this chapter. The care of the hair and scalp, both normal and diseased, is also discussed.

THE ANATOMY AND PHYSIOLOGY OF THE HAIR

To the superficial eye and for the purposes of those with a facetious turn, the hair appears like blades of grass piercing through soil. Actually, however, the hair is part of the skin itself, formed and supported by it. Those elements of nutrition and disease which affect the skin may also influence the hair. Hairs are epithelial stalks whose lower portions are housed in pouches or invaginations of the epidermis called follicles. The individual hair is grown from a pedicle at the base of the follicle, in a manner similar to that in which the epidermis is produced by its basal layer. The newly formed portion is pushed up by a still newer one that succeeds it. This endless chain of activity extruding its product through molds forms the hair. The end product of epidermal activity and maturation is keratin or horn. The latter is what constitutes most of the upper portion of hair or the parts above the surface of the skin.

Chemically the hair is the same as the epidermis, consisting largely of the various amino acids which combine to form a protein of the keratin family. The hair is extremely resistant to most chemical action; it is harmed only by strong acids or strong alkalies. The hair is an elastic substance capable of being stretched, when wet, to almost double its length without reaching the elastic limit; yet it is very strong, having a tensile strength about equal to that of mild steel.

Conditioning the hair, but not feeding it, is the oil produced by the oil or sebaceous glands communicating with the follicle. Sweat, too, undoubtedly has some influence on the state of the hair. The hair, then, is the creature and the image of the epidermal portion of the skin and is directly influenced by what affects the latter. It has a strictly passive role. It is lifeless.

Hair is straight or curly, depending upon the shape of the follicle and thus on the cross-section and compactness of the hair at the time it is formed. If the follicle rises in a straight line to the skin's surface, the cross-section of the hair will be circular, the component hair filaments will be lightly packed and the hair will be straight. If the follicle curves as it approaches the skin's surface, the cross-section of the hair will be oval, the component hair filaments will be tightly packed in places, and the hair will be curly. As the curve of the follicle increases, the cross-section of the hair also changes from oval to triangular or kidney-shaped, the hair filaments become more compactly packed in places, and the hair becomes increasingly curly.

The color of the hair depends a great deal on the presence and quantity of propigment materials brought to the mothering base and fixed at the time the hair is formed. The greater the number of pigment granules (called melanin) deposit in the hair, the darker the hair. Melanin is believed to exist in only two colors, the relative amounts of the two types of melanin present in the hair determine the shade or hue. Gray or white hair results from the failure of propigment materials to be fixed in the hair at the time that it is formed, or their removal later as with bleaches. The presence of air spaces within the hair is said to be a factor also.

The more we know about hair the easier it is to note that hairs collectively and individually are governed by strict patterns. Hairs do not grow continuously, but in something like fits and starts. There are periods of rest and active growth. The extent of these alternating periods seem to be fixed for life. Even hairs that are but millimeters apart on the scalp may vary considerably in their growth characteristics. The maximal length to which a hair grows and how long it takes is more or less fixed. Those hairs which are influenced by the sex hormones have added variables. Axillary and pubic hairs, of course, become lengthened after puberty. Another evidence of the patterning of hair growth is seen in the difference in the shape of the area of lengthened hair over the lower abdomen in the two sexes. In like manner, the hair production and attrition on the scalp of the two sexes is different. What makes many men bald we do not know, but there are fewer bald women. Moreover, bald men are not unique in their families. Aside, however, from the manifest influence that sex hormones have on hair of some parts of the body, little else that men know or have contrived has succeeded in attempts to modify hair growth or caused it to luxuriate. Rather, for the most part, they have retarded or abolished it as with the use of thallium and the x-rays. With minor exceptions, neither creams nor any other applications yet devised have changed the fixed growth pattern of a hair, even though the texture, color, or quality were otherwise modified. Hair growth then is not easily influenced and it is well to keep this in mind when listening to claims and counterclaims for various procedures, as with washing by one means or another.

REASONS FOR CLEANSING THE HAIR

There are two principal reasons for cleansing the hair.

1. **Health Reasons.** The hair and scalp must be clean in order to be healthy.

The same kind of soil collects on the scalp as collects elsewhere on the skin, but frequently to a greater degree. The extra soil results both from within and from without. The greater number of sebaceous glands in the scalp, relative to the number in most other equal areas of the body, makes for a relatively high amount of inspissated sebum on the scalp and hair. In addition, there is some perspiration, and the usual amounts of dead skin that are deposited on the scalp and to some extent picked up by the hair. The hair because of its great surface area, and particularly since it is at least somewhat oily, picks up dirt and accompanying bacteria from outside sources more readily than do other parts of the body. The soil as it accumulates on the scalp and hair provides a breeding place for these bacteria and other intruders, the most common being head lice. These breeding places and most of the bacteria can be removed effectively by cleansing.

2. **Esthetic Reasons.** The hair must be clean in order to be attractive and free from objectionable odors.

AVAILABLE CLEANSING MATERIALS

1. **Soap.** Soap is the most widely used cleansing material. It is usually applied in liquid form because when cake soap is rubbed directly on the hair it is not completely dissolved and thus may not be removed completely during rinsing; also when cake soap is rubbed on the hair it causes the hair to tangle which is objectionable, particularly to women. Liquid soaps—called shampoos, can be purchased as such or can be made in the home by dissolving a mild cake soap.

Effects of Using Soap. (A) *Removal of bacteria and their breeding places.* Soap in and of itself without the addition of antiseptics has an effect on bacteria. The accumulation of dust, oil, and epithelial debris in the scalp favors the presence of bacteria. The clean scalp harbors relatively few bacteria. Washing removes not only accumulations of detritus but the bacteria themselves. The surgeon does the same for his hands in his scrubbing ritual. Doubtless a good part of the bacteria are removed by mechanical means alone. If the washing is not energetic enough to succeed in irritating the scalp, the cleansed surface may be depended upon to arrest the activity of the remaining organisms by its inherent self-sterilizing property.

(B) *Alkali effect.* Some investigators have felt that soap does damage, not so much by its removal of the oil materials of the skin and hair, but by its alkali. To be sure, good toilet soaps and shampoos contain a minimum or are merely free of alkali. Nevertheless, in the use of soap with water there is hydrolysis and separation of the combination of fatty acids and alkali. So for all purposes the use of soap entails the exposure of the skin and hair to alkali. With good soaps, the amount of this alkali as measured by the pH of the solution is 8.5 to 10.5. This is not excessive, except for a very few individuals or individuals with certain diseases of the skin. For normal skins, *too much has been made of this alkali factor;* it may be safely ignored if a good soap is used. With some diseases of the skin, the skin may be found to be sensitive to materials having an alkaline reaction; under these conditions the use of soap solution in any form is contraindicated. The normal pH of the skin is between 3 and 6, but after washing with soap the pH is 9 or even higher. Although the skin quickly returns to its normal pH it may be undesirable with certain diseases to alter the acid mantle of the skin.

(C) *Irritating effect of soaps made with certain fatty acids.* As mentioned above, most people, particularly women, find it highly desirable to use soap in liquid form. Soap shampoos, in order to be acceptable, must have the following properties:

1. Be liquid in high concentrations. The high concentrations are necessary in order that the amount of soap applied to the hair be sufficient for cleansing.

> 2. Have excellent lathering properties. Consumers like the feel of rapid, abundant lather and are not satisfied without it.

Since the only soaps that have these properties are those made from the nut oils, practically all soap shampoos are made largely from one of these oils, namely, coconut oil. These soaps have a serious handicap in that they are not as mild as soaps, such as toilet and white floating bars, made largely from tallow and similar fats. As a result of their primary irritating properties, the coconut soap shampoos frequently cause a stinging sensation when used, and may, at times, cause a dermatitis. Because of this, other vegetable oils—olive, soya bean oil, etc., have been used in place of some or all of the coconut oil in some shampoos. The resultant shampoo is definitely milder, and, hence, from the medical point of view is to be preferred; but consumers do not react very favorably to this type of shampoo because it is available only in less concentrated solutions (concentrated solutions form a gel) and because it does not give a good lather.

(D) *Allergic effects of soap.* Soap itself is not an allergenic material. Soaps because of their dyes or perfumes may be allergenic in a few rare cases. The factor of dye may be avoided by using non-colored soaps, and the factor of perfume may be overcome by changing to a non-perfumed soap or at least to a soap with a different perfume. Only pure soaps should be used, because certain builders and fillers if used may cause an allergic condition. The irritation produced by all allergens is apt to be more prolonged on the scalp and contiguous sites since the mass of hair with its enormous surface furnishes an excellent anchorage for these allergens.

(E) *Appearance of hair after washing with soap.* The major disadvantage of soap is not medical, but is chemical. It results from the fact that soap combines with the salts of magnesium and calcium in hard water to form insoluble soaps. These materials cling tenaciously to the scalp and hair and are extremely difficult to remove. They form a dull coating on the hair which diminishes its natural luster and, in very hard water, makes the hair harsh and stiff and extremely difficult to manage. In order to overcome this disadvantage of soap the best thing, where possible, is to use soft water. In years past, rain water was collected and used expressly for shampooing purposes. In the absence of soft water, the dullness and harshness can be overcome to some extent by the use of acid rinses. The familiar ones used in the home are vinegar and lemon. The acid reacts with the insoluble magnesium and calcium soaps to form soluble salts of these minerals which are rinsed away, leaving on the hair the fatty acid portion of the soap. This oily material allows the hair to be lustrous and soft. A deposit of such material, however, tends to collect dirt more rapidly and if it remains too long, will develop an objectionable odor.

2. **Medicated Soaps.** Medicated soaps are used much more on the continent than they are here. They have been advised for a number of diseases of the scalp and many people with normal scalps shampoo with these modified soaps. Lanolin may find use by a few who have especially dry scalps and hair, but it is not ordinarily thought of as a medicated soap, but rather as a superfatted soap.

Mercury bichloride is a frequent constituent of these fortified soaps, and is irritating to many when it is present in a concentration sufficient to be effective. The scalp is less likely to be irritated than the nearby parts, such as the forehead, face, and the ears.

Tar soaps are the most popular of this class. There is no universal objection to their use, although many dermatologists question their efficacy. Some people are sensitive to tar, even when present in concentrations too small to be a primary irritant.

Sulfur in soap is used far more commonly abroad than in this country. The sovereign remedy for seborrhea and its group of diseases is sulfur, but little can be accomplished against them even by sulfur by so short an exposure as it takes to wash the hair. For persons exposed to lead, sulfur soap for the shampoo may be indicated just as for the rest of the skin.

Salicylic acid in soaps is subject to almost the same comment as for tar. As to the incorporation of borax, boric acid, witch hazel, and substances of similar blandness, they seldom do any harm, but the same may be said about their chances of doing good.

The presence of soap on the scalp and hair in taking the shampoo is so fleeting that even when strong medicaments are in the soap, they can do little good toward the eradication of disease. If such ingredients are advisable, it would be better to apply them incorporated in ointments or lotions to remain in contact with the scalp and hair for a prolonged period. If soaps of such potential harmfulness are used, this should be done only on the advice of a physician. The ignorant are apt to accept them in soap as part of a commonplace, household object of safety.

3. Synthetic Detergents. During the past fifteen years, a number of materials have been developed which, like soap, have cleansing properties, but unlike soap do not form a scum with hard water. The most widely used of these synthetic detergents are the sulfated esters—the various alkyl sulfates, sulfated monoglycerides—alkyl aryl sulfonates, etc. When used as shampoos for the hair they compare with soaps as follows:

(A) Removal of bacteria and their breeding places: about the same as soap.

(B) Alkali effect: since they are neutral (pH approximately 7.0), they have no alkali effect.

(C) Irritating effect: this depends on the synthetic detergent. They can be very mild; the most popular ones are at least as mild as the mildest toilet soap.

(D) Allergic effects: none of the popular synthetic detergents are allergic materials; thus, they are in the same class as the soaps.

(E) Appearance of hair after washing with synthetic detergent: the major difference between soap and synthetic detergents lies, not in their medical effects but in a chemical reaction. The synthetic detergents do not react with the calcium and magnesium salts in hard water to form insoluble soaps. Thus, they leave the hair soft, lustrous, and easy to manage even if the washing is done in hard water. Thus, unlike soaps, they do not require acid rinses.

4. Neutral Oils. The scalp like the rest of the skin is oily and, therefore, some people feel it should be cleansed with oil. The hot oil treatments and shampoos are based on this idea, especially where the scalp and hair are dry. This method has gained acceptance by relatively few. For the large majority, oil cleansing of the scalp is an expensive luxury or is unsatisfactory because of its messiness. Nevertheless, in certain diseases, oil cleansing of the scalp may be desirable and useful.

5. Sulfonated Oils. These materials are made by the reaction of sulfuric acid with certain vegetable oils such as olive and castor oil. Shampoos are made from them, generally by mixing them with a fairly high proportion of neutral oil which may be any one of a number of vegetable oils, or in some instances with mineral oil. These materials have the advantage of overcoming some of the hard water difficulties of soap. On the other hand, they do not form a lather and this acts as a psychological bar to their popularity. The cleansing action of soap is so commonly and intimately associated with the property of lathering that it is difficult to uproot the belief that it is dependent upon it. These oil shampoos leave a film on the hair which acts much like the fatty acid film discussed above in that it picks up dirt rather quickly.

6. **Demulcents.** Various demulcents have been used and still have a vogue. One of these is the egg, advised especially for bleached hair. The yolk and albumen portions are applied separately and rinsed out with water. Unquestionably dirt, scales and excretions can be removed in this way, but the method is repellent to most people. I see no particular virtue inherent in it. If bleaching has made the hair feel stiff and straw-like this may be mitigated by proper applications of oils and medicaments and still permit the use of ordinary detergents.

7. **Dry Powder Shampoos.** Powders have been employed for cleansing the scalp, but their use is rare. They consist of non-gritty finely divided materials, such as orris root. They may be useful where the scalp is oily. Their use is inconvenient and their complete removal difficult. The powder which remains attracts sebum and epithelial detritus, which cakes and hardens at the base of the hair. For this reason dermatologists hesitate to prescribe pastes or ointments containing these powders for application to the scalp.

8. **Miscellaneous.** There are still other substitutes for soap in addition to those described above. They either do not lend themselves to use on the scalp or they have not been made sufficiently available for an opinion. Some of these materials include powdered oatmeal, cornmeal, flaxseed, soap tree bark, as well as other related materials, powdered and mixed with vegetable or mineral oils. Some minerals, such as bentonite, fuller's earth, and soapstone, could, but had better not, be employed.

CARE OF THE NORMAL HAIR AND SCALP

1. **Frequency of Washing.** The purpose of washing the hair is simply to keep it clean. How often this should be done varies considerably and depends on several factors. Those who live in industrial centers where there is much smoke and dust in the air require more frequent shampoo-

ing. The amount of oil in the hair is an important factor in determining how often it should be washed. An oilier scalp attracts more dirt just as an oil mop gathers up dust from the floor. Moreover, the secretions tend to accumulate and break down. Exfoliated elements of the skin, too, accumulate and become admixed with the oil and sweat to mass into a caked layer. The number of bacteria increases with the presence of these added elements, probably because the normal self-sterilizing capacity of the scalp is interfered with by this interposing detritus. The presence of these multiplied numbers of bacteria becomes a potential threat for infection. This is all the more possible with the scratching induced by the itching of an unclean scalp.

There are, therefore, several variables governing the frequency with which the hair should be washed. This means that hardly any two people have exactly the same indications for washing hair any more than their facial expressions resemble one another. It is hopeless, therefore, to be dogmatic as to how often to shampoo. For most people it may be done at intervals ranging between one and two weeks. Those who live and work where there is little dirt or dust and whose scalps are relatively dry could get along with washing the hair once a month. The worker exposed to much smoke and grime with sufficient oil secretion may wash his hair every day.

2. How to Shampoo. The method of washing need not be complicated to be efficient. The elaborate ritual practiced by some of the professionals is not necessarily objectionable; those who find these courses attractive often avoid the simple self-shampoo which they find a chore and drudgery. It is easier to wash the hair when there is plenty of water available. A shower is excellent and a sprinkler arrangement attached to a faucet is next best. There should be sufficient changes of water if a basin is used. After wetting the hair and scalp thoroughly, the soap or other detergent is applied and rubbed up. This is followed by rinsing and then another soaping if necessary. One soaping sometimes suffices, but more frequently two soapings are needed; if the hair and scalp are particularly dirty three soapings may be required. When the hair is thoroughly cleansed, the shampoo should be rinsed completely from the hair. If soap has been used, an acid rinse of vinegar or lemon juice should be used to remove the precipitated lime and magnesium soap. Rinses containing dyes and bleaching agents are sometimes used. One of the common ones is with henna. The vegetable dyes are the least harmful, but even their use may be overdone. All of them can become allergenic, so that their use invites the risk of prolonged irritation just as when other hair dyes are employed.

It makes a difference as to what rinse is used with a particular color of hair. Lemon rinses have some bleaching qualities. Hair dressers use them generally on natural or artificially blond hair. The henna rinses and others which coat the surface of the hair will give a resultant color depending on the thickness of the coating and the original color of the hair that shows through the artificial layer.

After rinsing, the excess moisture should be removed by a towel. In the case of most women the hair will now be set into waves or curls and allowed to dry in this condition. In drying the hair, extreme heat is to be avoided. In the interest of time saving, however, most beauty salons use mechanical driers which dry the hair thoroughly in somewhat less than an hour. It is frequently said that such mechanical driers may have an adverse effect on the scalp. If the driers are operated properly, however, such an effect is temporary and consists merely of a too dry skin.

Keeping the hair clean brings out its natural wave and is not inimical to hair that is permanently waved. Proper washing removes or prevents matting and gives the hair fluffiness and sheen.

Some women want to know whether washing acts qualitatively the same on the bobbed as the uncut hair. There is, of course, no difference, except that longer hair arranged some ways accumulates more dust and is cleansed and rinsed with greater difficulty just as it requires longer to dry.

In the same way there is no fundamental difference in the method of or results from shampooing hair of different color. Soap does not interfere with pigment. Some care must be given the hair that is excessively bleached, because it is brittle and fractures readily. It needs the use of a bland oil or grease before shampooing.

3. Importance of Brushing. A century ago brushing the hair was as much a part of the daily routine of women as eating and sleeping. In recent years, however, the importance of brushing has been somewhat forgotten. Short hair has probably contributed to this. However, the hair brush properly used can be an instrument contributing to both the health of the scalp and beauty of the hair. Brushing the hair will help keep it free of extraneous dust and dirt and will polish it by causing the excreted sebum to be distributed along the entire hair shaft. The vigorous brushing of the hair will also stimulate the scalp and tend to make the sebaceous glands function properly.

It is just as important to keep the comb and brush used on the scalp as clean as the scalp and hair itself. The ideal procedure would be to wash the comb and brush whenever the hair is washed.

4. Application of Oils and Grease. Some people with insufficient oil are irritated by the amount of shampooing it takes to keep their hair clean. They need the application of a bland oil or grease. This may be made before or after the shampoo or both if the scalp is very dry. Petrolatum or better still liquid petrolatum of a light variety is of value. Vegetable oils, such as olive, sesame, or peanut oil, are acceptable. Lanolin is excellent. It may be used by itself or, better still, mixed with petrolatum or one of the vegetable oils. The odor of lanolin is objectionable to many and may be masked by the addition of some pleasant scent.

CARE OF THE SCALP IN INFANCY

There is considerable difference of opinion regarding what is appropriate for cleansing the scalp of the new-born. The majority of pediatricians do not permit the use of soap. Some do not use any cleansing agent to remove the vernix, but depend on spontaneous separation. Others advise water or bland oil, vegetable or mineral. The use of soap for washing the hair may commence when the baby is ten days old. This forms part of the bath, which many pediatricians allow daily. If the scalp is dried by daily washing, it may be lubricated by bland oil. The presence of scurf on the scalp is no contraindication to the use of soap, but this can be supplemented by applications of boric acid ointment, one per cent of ammoniated mercury ointment, or some other suitable agent. Older children's hair is shampooed in the same way as that of adults. Extra care should be given to the selection of the brand of soap or synthetic detergent for the child, especially the young one.

DISEASES OF THE SCALP

The scalp and hair are subject to a number of diseases. Some not only permit the use of soap or synthetic detergent, but may benefit from it. Others do not tolerate it. In the presence of disorder of these parts, therefore, the use or prohibition of soap or synthetic detergent is part of the treatment, and thus makes a correct diagnosis essential.

Eczema. Eczema of the scalp may be dry and scaly or moist and crusted. With eczema, the skin on the scalp as well as on other parts of the body may be harmed by soaps or synthetic detergents, depending on the type of eczema. Some eczemas here are difficult to distinguish from dermatitis venenata which reacts badly to soap, or synthetic detergent. Oil is more advisable for the shampoo in the presence of these disorders. Soap or synthetic detergent and water help to remove the superficial crusts of impetigo and permit medication that follows to act more effectively.

Seborrhea. The cause of seborrhea of the scalp is not known although there are theories about its pathogenesis. Much has been said about the relation of soap to it. Neither the excessive nor infrequent use of this cleansing agent probably is directly contributory to the production of dandruff. The use of soap or synthetic detergent does modify the symptoms after they arise.

Washing benefits both the oily and dry types of seborrhea. The amount of scaling is temporarily reduced, but it soon returns unless additional treatment is instituted. There is an optimum interval for shampooing dry seborrhea especially. Too frequent washing accentuates its dry character and is irritating. Neglect permits the accumulation of scale and debris. The dryness engendered by the shampoo may be combated by the application of a sulfur pomade. The scalp with oily seborrhea should be washed often enough to keep the scalp free of oil. This may be every other day in some cases. Itching is a common symptom of seborrhea and is abolished or reduced at once with the shampoo. It slowly recurs, however, and becomes of increasing intensity until the next washing. Seborrhea is a frequent cause of hair loss. Washing may be considered a part of its treatment and in that respect retards the progress of alopecia. Some have contended that it is bad to wet the hair, but I think there is no good proof for this. My observations are that wetting the hair does not accelerate hair loss and that, contrariwise, the avoidance of water in favor of oil or other cleansing methods results in just as great a fall.

Seborrheic dermatitis even when it is exudative permits soap or synthetic detergent shampooing. The crusts are separated by this means and this allows the medicaments to act more effectually. An alternative to the use of soap or synthetic detergent is oil. The scales and crust may be loosened with the latter and some scalps tolerate it better. Washing loosens the profuse and heavy scale that frequently accompanies psoriasis of the scalp, and this makes other therapeutic measures more effective. The employment of a hand brush for this purpose aids, but its over-zealous use irritates. The same may be said for the scaling of two much rarer diseases, pityriasis rubra pilaris or Devegie's disease, and keratosis follicularis or Darier's disease.

Lice. The shampoo is an integral part of the treatment of pediculosis capitis. After the application of a preliminary antiparasiticide, such as a diluted kerosene, the hair is thoroughly washed with soap or synthetic detergent and water. This helps to loosen crusts, detritus, and some nits. The fine comb here has one of its few proper uses. The shampoo is just as useful as a prophylactic measure against this infestation as it is in treatment after its presence.

Ringworm of the scalp of children is autoinoculable, so that care must be exercised not to spread the fungus to new sites. Nevertheless, the use of soap or synthetic detergent is indicated to remove scales and crusts, and to remove loosened hairs. Antiparasitic applications, such as sulfur, applied to the affected patches as well as to the rest of the scalp often insures against the spread of the contagion in spite of the rubbing and friction in thorough shampooing. There should be after-care of basins and utensils used in the shampoo to prevent the infection of others.

There is no contraindication to the use of soap or synthetic detergent in the other patchy alopecias. These include, besides ringworm and favus, lupus erythematosus, syphilis, alopecia areata, folliculitis decalvans, and pseudopelade. There are follicular pustules in folliculitis decalvans, but progress of the disease is slow and irregular. Proper antiseptic measures are undoubtedly sufficient to overcome any adverse tendencies that washing might have.

Miscellaneous. There are a few disorders of the hair, mostly congenital, which make the hair break more easily. This group is represented by such entities as trichorrhexis nodosa and monilethrix. It is true that manipulation of the hair with such affections tends to fracture them, but they do so anyway. There would be only minor aggravations of this, which would not be sufficient to make shampooing inadvisable.

The axillary hair attracts and holds the copious secretions from those parts. The materials are prone to decompose and become offensive. It is part of elementary hygiene to keep the axillae clean with soap and water. Many practice shaving of the axilla, but this is unnecessary to obtain acceptable cleanliness. The use of mild antiseptics and astringents secondary to washing is satisfactory care for almost all individuals.

6

Soaps for Industry and the Industrial Worker

CAREY P. McCORD, M.D.

The hard hand of toil is covered with a skin traditionally untouchable by wind or weather, by acid or solvent. The facts are otherwise. Next to infants, the sick, and possibly the aged, industrial workers have skins the most vulnerable to injury from external irritants. The reason for this is clear. Industrial workers, always with exceptions by the millions, go about their duties in an environment made abnormal as to skin functioning through continual or frequent exposures to water, oils, solvents, astringents, dusts, abrasives, grime, paints, waxes, along with scores of other possibilities. In meeting the joint responsibility of employer and employee to maintain healthy skins, the worker needs good soaps properly used.

THE EMPLOYER'S POSITION

In the small office or plant, the provision of soap may be a simple matter. Individual cakes of soap of the worker's choice may be made available without great wastage. The majority of workers would elect cake soap. In the large plants, particularly those above a thousand workers, soap distribution without significant wastage is difficult. Practical considerations hamper the use of cake soap. Requirements for janitor service measurably are increased thereby. Although the dangers of disease transfer are slight, many workers object to sharing cake soap. Thrown on the floors, the number of accidents from slipping is increased. In many plants individual lockers are not supplied so that there is little opportunity for the storage of individual soap cakes. Practical requirements including overall costs suggest the dispensing of liquid or powdered soaps. Frequently, both types are supplied thus giving some choice to the worker. No soap, however good, will satisfy all workers. A fair percentage prefer to supply their own soap usually in cake form which they keep privately in lockers when available; the worker's choice of his private soap often may not be commendable.

SOAP IN INDUSTRY

Quite apart from soaps employed for hygienic purposes, many industries use soap in work processes. Scores of such industrial soaps are employed and in hundreds of operations. While many such operations are fully automatic, a fair number necessitate exposure of the worker's skin. Although the prime consideration in this chapter is soaps for hygienic purposes, it may be profitable to introduce a limited presentation of the trade application of soaps.

Soaps, because of their wetting, emulsifying, and cleansing powers, have found extensive use in industry. The kind of soap chosen for any particular industrial operation depends on the industrial operation and its objective and only slightly, if at all, on the effects that the soap may have on the worker. Fortunately, however, the types of soaps required for industrial processing are usually high quality and mild. Some of the other industrial materials mixed with industrial soaps may possess greater irritant properties than the soap itself. In some instances it appears proved that the soaps provide some degree of protection of the skin against these known irritants. In general, it is rare to disclose a dermatitis due to the soap used for industrial processing. Even so, physicians should be apprised of some of the important industrial applications of soap and recognize that on occasion they might be responsible for this occurrence of contact dermatitis.

The industrial operations in which soap is used may be divided into two groups: (1) those in which the process does not normally require the worker to touch the soap solution or materials wet with it, and (2) those in which the process requires the worker to touch the soap solution or materials wet with it. By far the greatest amount of industrial soap is used in operations in the first group and in these no precautions, other than normal care, are necessary. The following are some typical procedures normally *not* requiring the worker to touch the processing soap solution or materials wet with it.

1. **Washing of clothes** by industrial laundries.
2. **Considerable textile processing,** such as
   - (a) Scouring of raw wool.
   - (b) Scouring and dyeing of skeins.
   - (c) Scouring of piece goods.
   - (d) "Soaping off" of printed textiles.
   - (e) Dyeing of some fibers and fabrics.
   - (f) Kierboiling of cottons.
3. **Metal Cleaning in Many Industries.**
4. **Synthetic Rubber Manufacture.** Soap is used to keep the butadiene and styrene in emulsion during polymerization.
5. **Metal and Wire Drawing.** Soap, either dry or in liquid form, is used to lubricate the molds.
6. **Metal Stamping.** Soap solutions are used to lubricate the metal stamps, for instance, for cartridges.
7. **Insecticide Spray Manufacture.** These are soap emulsions of insecticides such as pyrethrum, copper sulfate, arsenites, etc.
8. **Washing Fruits and Vegetables.** Soap solutions are used to remove insecticides, bugs, and organic debris.

In the above processes the careless worker may allow some soap solution to splash on him. At times, such as when a breakdown occurs, even the careful worker must touch the soap solutions or materials wet with them. In these cases, the worker will rarely suffer harm if he washes and rinses his hands immediately and if the event is not repeated at too frequent intervals. However, a dermatitis may result if the periods of contact are frequent enough. The organic debris on raw wool, dyes on dyed yarns and fabrics, chrome salts and gums on printed textiles, caustic present on cotton during kierboiling, solvents on metals, little pieces of dirty metal from metal drawing, carbon black and organic compounds in rubber, etc., are some of the more likely irritants or sensitizing agents apart from the soap itself.

Procedures that are typical of those in the second group, i.e., those in which the process requires that the worker touch the soap solution or materials wet with it, are:

1. **The Textile Industry.**
   (a) The preparation (throwing) of silk and rayon fibers for spinning. The fibers must be soft and lubricated during spinning and subsequent operations; otherwise they would cut the spinners, knitting needles, etc. These fibers are made soft by soaking in lukewarm soap solutions containing oil. The soap used must have good emulsifying power and must dry to a soft film. Along with the soap in the soaking solution there are oils (usually inedible grades of liquid oils such as neat's-foot, olive, etc.), alkaline salts, water-soluble dyes (in order to identify the batches of yarn for subsequent processing), and, of course, the fibers themselves with whatever impurities they may contain, such as the protein material present on silk fibers. The worker handling the soaked fibers may develop a dermatitis. In such a condition it is difficult to say just what caused the dermatitis; most probably there is no one cause.

   A neutral soap made from liquid fats or fatty acids such as oleic acid is the safest soap that can be used, but even its use may not prevent the dermatitis because of the continual exposure and the other factors.

(b) The "fulling" of woolen goods. The woven or knitted piece goods are pounded in a "mill" until the individual fibers become interlocked with each other to give that soft, luxurious finish so much desired in woolen goods. In order to facilitate the movement and intermingling of the fibers during the "fulling," the piece goods are soaked with a "fulling" solution which is a soap gel frequently containing alkaline builders. The worker who handles the woolen goods after the "fulling" may develop a dermatitis, but here again it is difficult definitely to identify the cause. For the "fulling" operation, well-made commercial soaps made from liquid fats such as olive or fatty acids such as oleic are usually used, since they give the best "fulling" action and rinse out easily afterwards; fortunately these are mild. The worker's repeated contact with the wet soap unquestionably conditions his skin so that it is susceptible to penetration and the added alkalies, particularly if used in large amounts, will cause irritation; small pieces of the woolen fiber may penetrate the soft skin and act like any other foreign body; usually the fibers have been dyed and the dyes may have a sensitizing effect; dirt and oils on the fibers may also penetrate the soft skin and be irritants.

2. **Lubricant for Molds for Rubber.** The molds are coated with a neutral soap solution prior to vulcanization. The vulcanized article with some adhering soap must be removed from the mold. The soap is usually dry by this time and hence the usual skin-softening effects are not apparent.

3. **Cutting Oils.** Soaps are employed to make water and oil emulsions; these emulsions are used to cool many kinds of metal-cutting tools. The employee who handles the cut-

ting tool and the metals being cut is in occasional or frequent contact with the solution.

4. **"Board" Scrubbing in Dry Cleaners.** Soap solutions are scrubbed on to dirty spots—cuffs, pockets, collars, etc., prior to dry cleaning. The employee doing the scrubbing frequently does other work such as "spotting" with solvents, etc., which may irritate his skin.

5. **Soap Manufacture.** A great many jobs in the soap industry require the continued handling of soap. A typical procedure is the handling of large slabs and individual cakes of wet soap during the cutting operation. It is interesting to note that these workers rarely develop any dermatitis, and that the soap industry is among the lowest in incidence of industrial dermatoses. The environment of the soap worker is practically free from those hazards present in many other industries—small foreign bodies such as metal turnings, fibers, dirt, etc.; chemicals such as solvents, acids, alkalies, dyes, bleaches, etc.; and oils and greases which hold dirt, bacteria, etc.

KINDS OF SOAPS USED FOR INDUSTRIAL PROCESSING

The kinds of soaps used for industrial processing vary considerably depending on the purpose for which they are to be used. The most commonly used raw materials are tallow and oleic acid—both containing a high percentage of long chain fatty acids and, hence, quite mild.

During recent years a great number of synthetic detergents have been produced. In some specific respects these have been found to be superior to soap and hence have been used in place of soap in many industrial processes where a particular result is desired. Their application, however, has not changed the fundamental problem of the effect on the worker of the soaps for processing, for continual exposure to the synthetics as well as to soap reduces the skin's resistance to penetration by potential irritants or sensitizers present in the industrial environment.

Government specifications for the commercial soaps that it buys are as follows:

CHIP SOAP

	Maximum	*Minimum*
Moisture and matter volatile at 105° C. (per cent)	10.0	....
Sum of free alkali, total matter insoluble in alcohol, and sodium chloride (per cent)	4.0	....
Free alkali, calculated as sodium hydroxide (NaOH) (per cent)	0.2	....
Matter insoluble in water (per cent)	1.0	
Anhydrous soap (per cent)	....	85.0
Titer of the mixed fatty acids prepared from the soap		39° C.
Rosin	None	....

POWDERED SOAP

	Maximum	*Minimum*
Moisture and matter volatile at 105° C. (per cent)	6.0	....
Sum of free alkali, total matter insoluble in alcohol, and sodium chloride (per cent)	4.0	....
Free alkali, calculated as sodium hydroxide (NaOH) (per cent)	0.2	.
Matter insoluble in water (per cent)	1.0	
Anhydrous soap (per cent)	....	89.0
Titer of mixed fatty acids prepared from the soap	...	39° C.
Residue retained on a No. 12 sieve (per cent)	1.5	....
Rosin	None	....

SOAP FOR LOW TEMPERATURE WASHING

	Maximum	*Minimum*
Matter volatile at 105° C. (per cent)	7.0	....
Sum of free alkali or free acid, total matter insoluble in alcohol, and sodium chloride (per cent)	4.0	....

	Maximum	*Minimum*
Free alkali, calculated as sodium hydroxide (NaOH) (per cent)	0.2	....
Free acid, calculated as oleic acid (per cent)	0.2	....
Matter insoluble in water (per cent)	0.5	....
Rosin	None	....
Sugar	None	....
Unsaponified and unsaponifiable matter (per cent)	1.0	
Anhydrous soap (per cent)	....	87.0
Titer of the mixed fatty acids prepared from the soap	25° C.	....
Iodine number (Wijs) of the mixed fatty acids prepared from the soap	93.0	
Acid number of the mixed fatty acids prepared from the soap	205.0	180.0
Residue retained on a No. 12 sieve (Class B only) (per cent)	1.5	

THE WORKER'S SUBSTITUTES FOR SOAPS AT THE FACTORY

The average worker, like the average person, finds it difficult to keep clean. Looking for short cuts and having an aversion for the mechanical scrubbing so necessary, workers in myriads resort to cleaning with whatever chemicals may be handy. Gasoline, naphtha, kerosene, benzene, carbon tetrachloride, alcohols, thinners, and alkali coolants are favorites among a highly varied and frequently changing lot of substitutes for soap and elbow grease.

Just as the worker is prone to buy all manner of advertised thereapeutic nostrums, he equally indulges in soap nostrums, soap substitutes, soapless soaps, waterless soaps, and the like. In industry the wonder is not how much dermatitis but how little. On inquiry into the nature of some of the "special" soaps or substitutes eased into the factory, every shade of undesirable quality may be encountered, from harsh abrasives to caustics. Other undesirable soap items are those with a content of cresols, formaldehyde, carbon tetrachloride, trichloroethylene and some phenols. Some of the soaps highly prized as disinfectants promote infection secondary to direct irritation from the alleged disinfectant. All, or nearly all, of dematitis from improper detergents eventuate into compensability and frequently unjustly so. All considered, the situation places on the employer a willingly accepted responsibility to provide good soaps, in good dispensers, and fully accessible.

THE WORKER'S HOME SOAP

The soap of choice in the home may determine the employee's response to irritants at work. It is conceivable that many workers with a dermatitis might have escaped this if there had been either no irritants at work or no injurious soap at home.

Just as the worker is wont highly to prize some special cleaner kept in his locker on the job, others harbor these troublemakers at home. These include low-grade soap gels, some containing methyl alcohol and carbon tetrachloride. Naphtha emulsions bought from peddlers, salicylic acid soap made by a neighbor, or rarely a little home-made lye soap brought up from "Mississippi," are but examples of types and sources.

SKIN INUREMENT

It is a popular but fanciful belief that time and continued exposure build up tolerance to borderline irritants including soaps. This is, at best, a half truth. Many oldtimers may continue with impunity at work, promptly disturbing to the newcomer. Conceding some natural protection, these oldtimers largely are present because the ones without natural resistance have weeded themselves out into other duties. Without full recital of facts, it may be asserted as important but not invariably true that most inurement consists in physiologically increasing the thickness of the stratum corneum. Obviously, it follows that no soap which unduly removes the outer skin layer along with the natural skin oils is likely to be valuable in industry. Conversely, an achievement highly desirable but possibly unattainable is some soap or other skin application which in moderation will thicken the normal stratum corneum.

An analogous situation may be found in sun tanning. On the first day of the golf season, most individuals readily may sunburn. After a few exposures no burning may occur. In the meanwhile, a prized skin tanning has taken place. Textbooks, physicians, and common belief unite in proclaiming that the tanning acts as a protective umbrella. This may not be true or entirely true, since most pigment lies below skin layers first attacked in sunburn. Instead, protection may be due to an imperceptible thickening of the stratum corneum. The blackest of negroes with all their pigment may sunburn freely on occasion and, conversely, in some persons, albinoid areas will not tan or burn under ordinary sun exposure. But, this matter of stratum corneum thickening may be carried too far. In some tan yards, the handling of skins and hides in vats containing vegetable tannins may produce actual tanning of workers' hand skin until it resembles a morachella mushroom. Along with much thickened stratum corneum other changes arise until these skins are definitely pathologic. The contention is that for many classes of workers in skin irritants or near irritants, no soaps should unduly be permitted to remove the highly protective outer layer of the skin.

THE pH OF THE INDUSTRIAL WORKER'S SOAP

The pH of the skin itself may be low, possibly ranging from 3-7, but the skin does not well tolerate contact material with a pH near the lower range of normal possibilities for the skin. At the other extreme the skin appears to be little affected by pH values well into the alkali range. It has been stated that some patch tests with materials at or near a pH level of 12 have proved non-irritating. Many much used soaps provide a pH above 10. In industry, with materials other than soap a pH above 10 may cause skin inflammation involving some of those exposed and as far as determinable from alkali action alone. It appears desirable that no soaps procured for worker hygienic purposes possess a pH higher than 10.5.

ABRASIVES IN SOAP

Workers are intrigued with the idea that abrasives in soaps facilitate skin cleaning and save time at the washstand. Abrasives do help but excessive mechanical action is detrimental when a defatting agent or irritant has acted previously so as to render the skin more responsive to any agent. Very hard abrasives such as silica while harmless to some may not be sponsored for all. Less hard inorganic abrasives such as pumice are widely used and often without injury. Lately such soaps have been recommended in the treatment of some skin diseases where there exists an excess of keratin. Granting a wide field of blameless use of such soaps it is still to be remembered that the duties of large numbers of workers are such as to keep the skin of exposed members continually on the verge of inflammatory reaction. For some of such workers, the use of inorganic abrasives in soap may be undesirable. Some preference is here expressed for the organic abrasives, chiefly beet, wood, corn and corncob meals, together with rice husks and possibly other grain husks. Of these, cornmeal has proved one of the best single vegetable abrasives but it is not as satisfactory as mixtures such as corn and corncob meals together with rice husks and all in varying small sizes. However, when cornmeal is utilized unsterile, it will be or become infested with weevils. This requires infrared, ultraviolet or some other treatment adequate to the destruction of insects, larvae, and eggs. Protection after disinfestation and prior to soap introduction is requisite.

SOILS

The extraneous material lying on the skin and calling for removal is commonly referred to as soil. The extent of soil in industry varies with the industry and the particular job and at times on a day by day basis. As a rule, the removal of industrial soils from the skin is a more complicated problem than non-industrial cleaning of the skin. Industry does not lend itself to classification as to the degree of soil but on a general basis there is a natural grouping into three types now mentioned:

Group I. Lightly Embedded Soil, Readily Removed by Any Good Soap; Little Mechanical Action (Rubbing) Being Required. Office workers, storekeepers, sales people, workers in food industry, some light industries, textile workers, are examples falling into this group. Here the use of a neutral soap without added builders, solvents, or abrasives is sufficient.

The problem entailed for this group resides not so much in the choice of soap as in the method of dispensing. The larger the group to be served, the greater the difficulty. For any large group it becomes almost necessary to rely upon powdered or liquid soap which can be handled through dispensers. In this way the worker does not come in contact with soap previously used by others, nor is he tempted to remove cakes of soap supplied for the group. Liquid soaps in order to flow freely through dispensers must be potassium soaps largely made from coconut oil which fact at once introduces some objectionable qualities, particularly for those with sensitive skins. Liquid soaps are satisfactory for the hands but are less desirable for facial use. Liquid soaps commonly are not mild. Powdered soaps may be as mild as cake soap but they may not lather freely.

Group II. More Heavily Embedded Soil Removable Only with Considerable Mechanical Action Along with a Suitable Soap. Most industrial workers fall into this category such as in the mining, metal, and oil industries. Here, the use of a soap containing an abrasive that supplies the immediate mechanical action is indicated although non-harsh brushes may be satisfactory along with a good soap. The abrasive must be selected with care because coarse, harsh material although effective in removing of soil may damage the stratum corneum and thus pave the way for the action of offending materials. Already a preference has been expressed for a suitable vegetable abrasive over mineral abrasives but it is recognized that many workers safely employ mineral abrasive soaps.

Group III. Heavily Embedded Soil Which Is Not Readily Removed by Soap and Mechanical Action. The percentage of workers comprising this group is low, but in the aggregate the total number is high and may include painters, lithographers, some dyers, some road workers, and some chemical workers. For the majority, cleansing may be secured by longer scrubbing but this may be detrimental to uncoated portions of the skin. These industries present a series of individual problems all requiring special considerations. With many reservations and with sponsorship limited to minimal requirements, selected chemicals may be utilized along with proper soaps provided these potential irritants are well removed at the time and provided soothing creams or lotions containing fatty material properly are applied after washing in order to replace the natural skin oils that may have been removed in the process.

SUITABLE INDUSTRIAL SOAPS

Having in mind such considerations as wastage, safety, costs, janitor services, and varying degrees of water hardness, a number of soaps will be described. Primarily, these are projected for larger plants and other situations where the use of cake soap may not be suitable. Such soaps are recommended primarily as hand and arm soaps and are less suited for face cleaning. It is not claimed that such soaps are invariably free of skin-irritant possibilities since this may not be claimed of any soap.

Heavy-duty Granular Soap. For the dirtier, grimier trades utilizing the services of the majority of factory workers a soap formula is suggested. This same soap may be used in lighter operations and even in offices although other preferences are expressed.

Formula:

Total Soap (Calculated as Sodium Laurate)	46.0% Min.
(Powdered hand soap must contain not less than 12% Coconut Oil Soap)	
Fancy Tallow Stearate Soap 70%	
Extra Refined Coconut Oil Soap 30%	
Anhydrous Tetrasodium Pyrophosphate	6.0% Max.
Borax	3.0% Max.
Free Alkali	None
Moisture (at 110° C.)	10.0% Max.
Inorganic Abrasives	None
Mild Organic Abrasives	Balance
Such as cornmeal or equivalent. Fifty per cent woodflour and 50% cornmeal scrubber. Woodflour to be made up of selected wood, as maple, and of such fineness as to act in the crevices of the skin without "balling." The cornmeal to be of a coarser size to create sensation of hardness without having sharp abrasive action. Cornmeal to be treated to kill larvae.	
pH	10.2 or less

Note: As compounded, this should yield a free-pouring powdered soap which will not "ball up" under conditions of actual use or exposure.

This cleanser, with minor variations, has withstood the test of millions of man-year usage with no, or rare, skin reaction appearing and with a good degree of user satisfaction. A portion of the excellent results obtained is due to the two sizes of selected organic scrubbers which aid distinctly in the cleaning process (woodflour particle size not over 200μ; cornmeal and rice husks not over 500μ).

Such a soap works well in both cold and hot water although its use does not condone the absence of hot water in factories. Further, the rate at which this soap cleans is pleasing to employees eager to leave the plant premises for outside activities. Without altered formulation designed for hard waters, this particular soap may serve under many circumstances of unusually hard waters. Of course, a small percentage of workers "grouse" over this type of soap, but the same percentage would no doubt "grouse" over any other soap.

Light Duty Granular Soap. A lighter, smoother soap is desirable for office workers and those in manufacturing pursuits under conditions not conducive to greasiness and griminess. While the hard-working laborer may prefer and demand the soap that provides a feeling of roughness, this is not wanted by the white-collar group, and particularly by women office workers. This being true, a more desirable soap is now shown in formula.

Formula:

Anhydrous Soap		47.0% Min.
Fancy Tallow Stearate Soap	70%	
Refined Coconut Oil Soap	30%	
Anhydrous Tetrasodium Pyrophosphate		5.0% Max.
Free Alkali		None
Moisture (At 110° C.)		10.0% Max.
Inorganic Abrasives		None
Fine Organic Abrasives (Finer than in previous formula; white in color) Such as corncob meal, cornmeal, or rice husks. The foregoing materials to be ground to the proper degree of fineness; bleaching where necessary.		Balance
pH		10.2 or less

Note: The size fraction should be so graded as to prevent "balling" or "lumping" under conditions of actual use or exposure. This objective is most easily obtained by the use of two different abrasives of varying, though fine screen size (woodmeal particle size 200μ max.; other inorganic abrasive, 400μ max.).

Liquid Soap. Experience indicates that even the best of liquid soaps are not as satisfactory as an ably formulated powdered cleanser. This statement does not deny a field of satisfactory application in industry but this field chiefly is associated with offices and lighter fabrication operations. In many plants, powdered and liquid soaps in dispensers are placed alongside in the washing area giving the worker a choice and providing for inevitable dirtiness in excess of the capacity of liquid soap.

Formula:

Total Soap		40.0% Min.
Refined Coconut Oil Soap	30%	
Soap derived from higher fatty acids ranging from C_{16} on, such as olive, soybean, cottonseed, and castor	70%	
Water		60.0%
Adulterants		None
pH		10.2 or less

Note: To insure sustained liquid state, this type of soap is made with potassium hydroxide instead of sodium hydroxide.

Liquid soaps have variable amounts of water included which result in a cleaning product that appears cheap but which has a high unit cost. In addition to dilution with water, many liquid soaps have added material like glycerin, sugar, and ethyl alcohol to prevent freezing of the product with subsequent appearance of cloudiness which is objectionable from the sales standpoint. In some cases the added materials used to prevent cloudiness have caused skin irritation. Difficulties have been observed with some liquid soaps due to the presence of a high content of alkali. Irritation is sometimes observed from liquid soaps due to inclusion of an excessive amount of the coconut oil fraction of soap. The addition of wetting agents in liquid, as well as in powdered soaps, may accentuate skin damage if it does not cause damage in itself. The very nature of penetrating agents is such that the skin is softened and the natural oils removed to an extent that the skin is not normal. Attempts to introduce animal fats, such as lanolin, into the skin surface at the same time agents are being used which will remove fats cannot in any way relieve this situation.

SPECIAL SOAPS AND SPECIAL SITUATIONS

In some plants hot water is not provided. No soap will make hot water dispensable nor will hot water make a good soap dispensable. A mediocre soap and hot water are better than a good soap and no hot water. In many areas all water is so hard as to hamper the full action of the soaps described although experience suggests that the heavy-duty soap, as described, almost invariably will suffice in hard water areas. For such areas, modification that provides some betterment in soaps may be made. An analysis of water or a water sample sent to some soap manufacturers may lead to custom-formulated soap if the buyer is a big customer. On the whole, it may be better to install a water softener.

In late years much has been written about superfatted soaps. Obviously, a soap that leaves the skin of the worker with an oily film or at least leaves as much natural skin oil as was present before washing is desirable since so many of industry's work materials are skin defatters. So far, my experience has not shown the existence of a suitable soap of this character. Welcome will be extended to this quality in listing the features of good industrial soaps.

This period is one of growing application of wetting agents. One of the most attractive fields for wetting agents is to be found in soaps for the industrial worker. The wetting agent situation with regard to soaps involves no lack of skin-wetting agents. Instead, wetting agent action appears not to be compatible with soap action so that a modified concept of formulation may be required in order successfully to employ wetting agents. Workers dislike the absence of lather associated with some products containing wetting agents. The problem has not been satisfactorily met although some manufacturers have incorporated these agents in soaps. Some wetting agents are themselves irritants, but possibly not in the quantities likely to appear in that quantity of soap used daily.

A typical peculiar situation is here recited revealing the need for reliance on unusual soap products. A certain plant is located in an area in which the entire city's water is hard. At this plant, albeit large, no hot water was available to one department carrying out automatic screw machine work. About two hundred workers simultaneously developed "oil dermatitis." This common occupational skin affection is due chiefly to grime ground into the skin openings and left in place. An outraged skin rebels against the sustained presence of mechanical plugs. Although a dirt disease, the oil plays an essential part. The oil being of a heavy lubricating type is in itself not a common irritant nor are any contained bacteria important to the folliculitis. Bacteria always present on the skin are sufficient. The afflicted workers, when shown the thousands of plugged up skin openings, loudly and rightfully pleaded inability to secure cleanliness with the facilities provided for cleaning. In the plant dispensary an attempt was made to secure cleanliness with the soap and water available to the workers. This failed. Then as a demonstration, all two hundred workers, one by one, were properly scrubbed in the hospital. To do this, soaking in hot suds using a good soap was carried out (usually limited to the arms) for thirty minutes. After this, a well-known shampoo containing lauryl alcohol as a wetting agent, diluted about one in three with hot water, was mildly scrubbed on for five minutes employing a horsehair brush which obviously is less stiff than a vegetable fiber brush. By this time these treated skin areas were visibly and chemically clean. Thereafter, lanolin was rubbed into the cleaned areas and more lanolin supplied each worker for temporary use. The dermatitis regularly cleared, and among all workers who learned the meaning of real cleanliness, did not recur. Many workers still use the shampoo wetting agent even though not fully satisfactory. In that plant a soft hot water has been provided. The points to be made are manifest. Good soaps alone are not sufficient, and special problems call for suitable adaptations for soap *provisions.*

SOAPS FOR WORKERS WITH SKIN DISEASES

This chapter deals with plant, and not medical, experience. It is plant experience that some workers go about their duties for long periods with skin diseases. It is plant experience that some workers with skin diseases do not thrive on wet jobs nor profit by the use of soap and water or even water. Without invading the field of medicine, workers who have been advised by physicians to avoid soap and wetness may be encouraged to clean up with mineral oils, some vegetable oils, spindle oil, etc. Spindle oil, the lightest of lubricating oils, may best be known to the public as fishing-reel or typewriter oil. Rarely is this harmful. Important to industry, but apart from its responsibilities, there are well known to physicians soaps suited to the routine use of workers with chronic skin affairs. The one or two per cent of such workers should furnish their own soaps and limit their use to themselves. It is asking too much of any good industrial soap to be safe for all manner of skin diseases and at all times.

PATCH TESTS WITH SOAPS

The much used and abused patch test casually applied may not conclusively mark a soap designed for industrial use either as acceptable or prospectively injurious. Some irritant soaps may yield a negative patch result while good ones may provide highly positive actions even with vesiculation. Soaps themselves slightly wetted and held in place constitute a harsher procedure than accompanies the usual laving even though some soap remains after rinsing. Positive tests should be followed in many instances with others based on dilutions. Positive results with dilutions clearly are more significant than those from full strength.

Patch tests preferably should be made and interpreted by physicians. Yet the procedure is so simple that any intelligent person should be qualified, and particularly so, if some experience has been gained under the tutelage of a physician. For that reason a simple method is described and not all physicians may necessarily elect this method.

Assuming the soap is liquid (powdered or solid soaps require obvious variations), provide a small quantity of the soap as used (without dilution), two squares of a few thicknesses of gauze about 5 mm. to the side, two squares of clean cardboard of about cigarette carton thickness, but of better quality, and three squares of adhesive 1.5 inches to the side (preferably non-sensitizing adhesive). With forceps, lightly dip one gauze into the soap and then press out to moderate dryness. Apply to front of upper arm (alternate sites: front of lower arm, between shoulder blades, front of thighs); cover with cardboard which should be slightly larger than gauze (7 mm.); then securely seal with the adhesive. The cardboard is to secure pressure over the gauze; unless in firm contact with the skin, no result may occur. If necessary, use more adhesive to get a good seal; otherwise drying will occur and provide a higher concentration than is fair to the test. Some drying takes place at best.

For controls, run two other tests: viz., with the gauze wetted with water and the cardboard dry, both under adhesive. For comparisons between liquid and solid soaps due allowance should be made for the fact that liquid soaps are water diluted. Allow to remain in place for twenty-four hours unless discomfort earlier indicates a severe reaction. Occasionally, tests are continued for forty-eight, seventy-two, or ninety-six hours but such are not contemplated for this elemental procedure. On removal, do not read for at least ten minutes. The adhesive may cause some inflammation, which, while unwanted, is without significance to the test. Under the gauze and thereabouts there may be redness or vesiculation. The size, degree, and persistence all stand in relation to severity. Slight redness that fades within an hour may be disregarded. Severe reactions from high concentrations suggest primary irritation, but from low concentrations, sensitivity.

HOW AND WHEN THE WORKER SHOULD WASH

The best washing facilities obtainable by industry are valueless unless used. It may seem a bit elementary to devote space to the details of washing but the average worker is dirty after washing. This comment goes no further than hand and arm washing leaving to others the soil on the rest of the body. Assuming that management has done its part in furnishing proper soap, hot water, and possibly towels, the worker in taking over should be influenced by the following:

1. Wash frequently if the job demands hour by hour cleanliness as in the case of the typist handling carbon paper.

   Wash frequently if the work involves exposure to skin irritants that may be removed by washing as in the case of the chrome plater.

   Wash after every trip to the toilet.

   Wash before eating.

   Wash at the end of the work period.

   Few workers wash too often but, of course, there is such a thing as excessive washing. Better a little dirt than no natural skin oil.

2. Use as little soap as is required to attain cleanliness.

3. In using powdered soap always wet hands before contact with the powdered soap. If put on first, it is merely washed away by water.

4. In the soap-using period, use little water. Give the soap a chance.

5. Work up a lather. The millions of bubbles in lather play a part in skin cleaning.

6. Don't expect the soap to do all the work. Mechanically rub. Use a soft brush or at least a rag. The vegetable meal is just a wash rag in particle size.

7. Unlike surgeons, don't wash by the clock. Wash until visibly clean.

8. Rinse freely until all soap is removed. This takes more rinsing than you think. Don't finish off in ice cold water. The skin dislikes violent changes.

9. Inspect for dirtiness. It doesn't take a dermatologist to see a thousand plugged pores. If necessary, start all over.

10. Dry carefully. Deliberately dry between all fingers and around all nails.

11. If the labor has been hard or the scrubbing hard, apply a bland oily cream.

12. Avoid immediate outside chilling.

SOAPS AND THE HYGIENE OF WORKERS APART FROM SKIN WASHING

Apart from soaps used in industrial processing, janitors, scrubwomen, and scrubmen are exposed to soaps and other cleaning agents to an extent greater than the usual run of workers. Skin affections in this class of employment are fairly common. Some woes of workers from soaps and other cleaners arise from the cleaning of rags used by workers or garments worn by them. In some instances no soaps are used, but no attempt is here made to present the different methods of cleaning. With reference to rags as used in some large plants by the ton for wiping, drying, etc., alkalies are the chief offenders. Unless strong alkalies used in the wash are well removed by rinsing, subsequent handling may lead to dermatitis.

One episode connected with worker garments which is representative of many possibilities of similar nature occurred at a large-sized, unnamed plant. One morning, thirty male workers within a few hours complained of an acute dermatitis chiefly present about the back of the neck, wrists, ankles, with serpentine stripes on arms and legs. These workers were scattered over several departments; their work was highly dissimilar; they ate in different dining rooms; some were not conceivably exposed to any common irritant, but the lesions and distribution were similar and often identical. For several hours no common denominator was disclosed and meanwhile, about ten additional cases appeared. By this time it was discovered that all of these workers had been supplied on the day preceding or early on the same day with clean coveralls. This proved to be significant. The distribution of involvement well coincided with the heavier seams of the coveralls and the thickened portion of the coveralls such as the collars, the wrists, the lower hem, etc. It was then established that all of these coveralls had been received from a single industrial laundry vendor. The cleaning of oily, grimy overalls, coveralls, and aprons as worn by workers calls for severe cleaning procedures. At the vendor's plant it was found that along with various soaps and alkalies such garments were soaked in what by courtesy was termed "pine oil," but in fact was a crude wood derivative, highly irritating as established by patch tests. By custom, this "pine oil" detergent was followed by seven other washings or rinsings to remove all chemicals. At the period during which the coveralls under investigation were being cleaned, one day, only 50 per cent of the laundry vendor's employees showed up for work. As a consequence, a cleaning shortcut was carried out and these coveralls were rinsed three or four times only. Back at the plant small squares of coverall collars and similar materials were applied as patch tests and readily produced skin damage. The cause of the epidemic was precisely established and necessary preventive measures were clear. In the meanwhile, the total number of cases increased to sixty.

ONE EPIDEMIC ATTRIBUTED TO SOAP

Soap comes next to air conditions in work places as the cause of worker complaint. All manner of diseases from psoriasis to callosities lead to accusing fingers pointing in the direction of soaps. Not always is the soap manufacturer or vendor culpable as in the following occurrence.

In an undesignated factory with many departments, sixteen male workers who were not exposed to any chemicals in their work, within the period of about three days developed the same form of dermatitis of the hands and forearms with occasional face involvement. All of these workers frequented the same washroom. Otherwise there was no proved shared factor. Prior to medical inquiry these men established to their own satisfaction that the liquid soap supplied by the management was the offending agent. There was the usual incrimination and condemnation. Patch tests promptly carried out with this soap on some of these patients and on uninvolved persons led to active responses in twenty-four hours with some vesiculation.

Epidemiological inquiry established the fact that this soap had been obtained from a barrel in a central supply department and that various other departments were being supplied from this same batch and no difficulty had been encountered. The manufacturer's analysis was obtained from which it was found that no genuine complaint might be made. A reanalysis confirmed the original analysis. Patch tests with the central supply lot of soap led to negative results. Then came the denouement. The janitor from the department of worker involvement, in obtaining his soap supply from the central lot, negligently used a container richly contaminated with a severe irritant.

The manufacturer was relieved of his anxiety neurosis; the workers found some sadistic pleasure in having their opinions justified; the writer of this chapter was furnished opportunity to note that the matter of soaps in industry is far more complex than the mere reaching up to the pantry shelf and finding there a nice new cake of pure soap.

SUMMARY

There is a trite maxim to the end that the per capita consumption of soap is a yardstick of a nation's degree of civilization. It is less banal to state that proper industrial washing facilities properly used constitute a yardstick of intelligent industrialism.

7

Soap for Shaving

LESTER HOLLANDER, M.D.

INTRODUCTION

The matinal task of shaving has become the dictum of present-day male hygiene and facial style. It has been established over a long period of time. The art of shaving, pogonotomy, itself dates back to antiquity, and in Rome, in the time of the younger Scipio (second century B.C.), it had become a daily "must." Thus there seems little hope that this habit of civilized men will undergo any sudden or drastic or even noticeable change although the manner of the procedure of shaving itself may alter if the so-called electric shaver is further improved.

For the time being, however, and for the overwhelming majority of men, shaving will continue to be essentially a planing operation, accomplished by the use of a delicately sharpened steel blade either of the jackknife type, or one called a safety razor, which is so constructed that gross trauma (deep cuts into the skin) is not likely to occur because of the shallow exposure of the cutting edge of a removable steel blade.

Shaving is quite a complex operation, influenced by many factors having a bearing not only on the operation as a whole but on each other also. These factors include the individual person, the architecture of his skin and beard, the condition of sharpness of the razor blade, the shaving angle of the safety instrument, the use or abuse of softening agents, the quality and type of soap or soap substitute, the length of time available, the interval of time that has elapsed since the previous shave, visibility, dexterity, and even such an apparently remote condition as that pertaining to atmosphere. Although the chief concern here is soap for shaving, we cannot escape at least a brief consideration of some factors which influence the efficacy of shaving and the modus operandi of soap itself.

THE MECHANISM OF SHAVING

The object of shaving is actually to remove the visible and the palpable portion of the hair which protrudes on and above the surface of the skin.

Hairs are present[1] on all parts of the human skin except the palms, the soles, red portions of the lips, and ungual phalanges. They are threadlike, more or less horny structures, composed chiefly of keratin, a highly complex organic material containing nitrogen and sulphur. These fine cylindrical tubules are the highly specialized products of the deep-seated intradermal glands, the so-called hair follicles. In different races, in different individuals, in different locations, and also at different periods in the life of the individual they vary as to their presence or absence, and size, length, width, density, hardness, color, and the amount of their fatty sebaceous envelope.

There are three main varieties of hair: first, the soft long hairs such as those occurring on the scalp, beard, axillae, and pubes; second, stiff hair or bristles such as the eyelashes, eyebrows, hairs of the nasal and auditory orifices; and third, lanugo or downy hairs, which are fine, thin, hollow, colorless, soft, almost imperceptible filaments. In infancy the hair is of the downy and fine silk-like filament type, and with increasing age the hair becomes stronger, harder, and appears at adolescence on previously hair-free areas such as the beard and the axillae. Later in life, especially after the advent of advanced age, there occurs a decrease in number and also in color of the hair which remains.

The hair consists of a shaft or a stem which at its lower end forms a bulb and embraces the hair papilla. Most of the shaft or stem is visible as the thread-like filament covering the external skin surface. The outer layer of the hair shaft is kept supple by the presence of a fine layer of fatty waxy substance arising in the minute glandular structures of the skin known as the sebaceous glands. This substance varies in amount, in composition, and even in its presence or absence at various periods of the life of the individual, being most abundant during the period of adolescence and early adulthood.

Removal of hair by shaving is chiefly a mechanical operation which is facilitated by measures which lessen the resistance of the hair shaft to this procedure. Of these, lathering of the beard by soap or some substitute plays a most important part. Because the term shaving refers chiefly to the removal of the beard, the subject will be considered mainly from this particular viewpoint.

A man having twenty-four hours' growth of beard finds his skin in somewhat the following condition: The outermost horny layer of the skin, which is known as the stratum corneum and which was partially removed during the prior shave, has been practically all restored by natural processes. It is a film chiefly of keratin, approximately 0.025 mm. in thickness. This film contains wrinkles with a wide variety of depth, length, and spacing, depending on the age, state of nutrition, presence or absence of teeth, and other characteristics of the individual. It contains the openings of sweat glands and also the apertures through which the hair shafts protrude on to the skin surface itself. At spaced intervals where the skin surface overlies the hair follicles there is an elevation of approximately 0.050 mm. to be found in the form of a mound. The diameter of this mound at its greatest elevation is of the magnitude of two or three times the hair shaft diameter.

Thus, it is established that the bearded surface is uneven, but since it moves freely over the underlying structures, because of the intervening fatty subcutaneous layer, this unevenness is diminishable by slight stretching of the skin. This stretching may be brought about either by a properly designed guard on a safety razor or by the fingers of the free hand of the shaver. (It may be important to note that overstretching will increase the elevation of the mounds overlying the hair follicles, especially over the area of the chin; so much so that they will get into the line of the planing action of the razor blade and may be chipped off, thus causing excessive damage and some lasting discomfort.)

The beard hair itself in twenty-four hours will have a length of from 0.35 to 0.55 mm., depending on the season of the year and various other factors.[2] It will have a diameter ranging from 0.1 mm. to 0.27 mm., depending on the individual and on the portion of the face under consideration. (The coarsest hairs are frequently found on the upper lip.) It will protrude from the skin at an angle always less than 90 degrees, averaging 60 degrees, and sometimes less than 30 degrees; in the last case it may lie in a natural furrow or wrinkle. (This condition adds to the difficulty of removing it.)

When a sharp blade is passed over the stretched skin it meets little obstruction until it comes to the hair shaft itself. At this point its function as a planing tool becomes operative. If the blade edge makes an appropriate shaving angle it will plane off the hair without removing much horny layer. This planing operation, however, is carried out over a nonrigid yielding surface in which the hair will tend to turn over at the same time as it is being sheared, thus changing the resultant effect upon the hair shaft itself sufficiently that the hair end is left with an obliquely slanted whittled point rather than a blunt sheared end. This is especially true when shaving is carried on "with the grain." Such configuration is undesirable because it gives the shaver the impression of an incomplete shave.

A major requirement of close shaving is to avoid this unwanted whittling and to make the sheared end of the hairs as transverse and as blunt as possible. To do so the following have been found of value: [3]

1. The use of a sharp blade.
2. Shaving against the grain.
3. The use of an increased shaving angle. (This tends to remove some of the horny layer as well as hair itself. In many safety razors the shaving angle cannot be modified due to their construction.)
4. Softening the hair so well before shaving that the blade does not become dulled during the shave.
5. The use of thin rather than stiff lathers (see fallacies below).
6. Shaving over the skin more than once.
7. Bearing against the skin with some pressure during shaving.
8. Shaving with a slicing or slanting stroke after the blade has become dull.

DISCOMFORT CAUSED BY SHAVING

Discomfort occasioned by shaving is another important consideration. This may occur during the actual procedure of the operation, shortly after the shaving has been completed, or both. This discomfort may be immediate and/or subsequent, it may be of short or lasting duration, and each of these is occasioned by a different type of injury.

First, there is a temporary and immediate discomfort. During the act of forcing a razor blade through a hair there is a component of the force that acts in the longitudinal direction of the hair shaft, tending to tug upon its root. This force gives rise to "pulling" discomfort, the importance of which has been grossly underestimated. To reduce this component force and its attendant pain, a different list of precautions is suggested by experience: [3]

1. Softening the hair as much as possible.
2. The use of a sharp blade.
3. The use of a diminished shaving angle. (Loosening of

the handle of many double-edged types of razors increases the shaving angle instead of diminishing it.)

4. A slicing or slanting stroke.

The second type of discomfort is occasioned by the ablation of the uppermost layer of the skin. This is a normal by-product of shaving and may manifest itself in a certain amount of burning and stinging after shaving has been completed.

In order to make a quantitative study of this, an experiment was carried out.[4] The material accumulated on the razor from the result of shaving was washed off with a lather solvent. This lather solvent contained one part of ethylene dichloride and one and one-half parts of ethyl alcohol. It was further rinsed by decantation with the same solvent and then the entire slush thus obtained was centrifuged in graduated centrifuge tubes. This resulted in a sharply demarcated two-layer formation in which the compacted hair chips formed the lower layer and the compacted skin particles made up the upper layer. The demarcation was made distinct by the sharp differences in the color of these two, and thus each layer was easily measurable. Although the relative quantity of hair and skin removed in various individuals varied considerably, as the accompanying Tables 1 and 2 show, generally speaking, it appeared that for each two parts of hair one part of epidermis was shaved off. Photomicrographs were made of the shaved epidermal particles, which could be recognized as such. Further, the freshly shaved skin was examined by means of a small magnifier lens, the handle of which contained a small flashlight which gave the surface slantwise illumination. These examinations confirmed the fact that the trauma to the skin consisted principally in the excision of the horny layer and that most of the damage occured at the follicular hair shaft openings.

The third type of discomfort, which is the longest lasting, is occasioned by penetrating trauma, the nicks and cuts during shaving. In order to minimize the second and this last

TABLE 1

THE AVERAGE QUANTITY OF SKIN AND HAIR REMOVED IN SHAVING EACH TWENTY-FOUR HOURS BY DIFFERENT PERSONS

Individual Number	*Quantity in cc.*	
	Skin	*Hair*
1	0.50	0.63
2	0.32	0.60
3	0.30	0.30
4	0.30	0.29
5	0.19	0.29
6	0.30	0.21
7	0.15	0.30
8	0.13	0.23
9	0.17	0.20
10	0.17	0.17
11	0.25	0.10
12	0.12	0.14

TABLE 2

QUANTITY OF SKIN AND HAIR REMOVED IN SHAVING (COMPARISON FOR AVERAGE AND CLOSE SHAVING)

Test Number	*Quantity in cc.*		*Notes*
	Skin	*Hair*	
39	0.11	0.22	Once over, dull blade
40	0.15	0.05	Second time, sharp blade
6	0.32	0.28	Once over, fair blade
7	0.04	0.04	Second time, sharp blade
26	0.14	0.14	Once over, fair blade
27	0.11	0.05	Second time, same blade
16	0.28	0.32	Once over, fair blade
25	0.50	0.26	Once and twice, same person

type of shaving discomfort, a third and still different list of precautions is needed, as follows: [3]

1. The use of a somewhat dulled blade, not a sharp one (see fallacies below).
2. The use of a diminished shaving angle made by the blade with the skin.
3. Shaving only once and with the grain.

4. Complete softening of the hair before shaving.
5. The use of stiff lather instead of a thin one, which thus acts as a protective film between the skin and the blade edge.
6. The use of light pressure during shaving.
7. Avoidance of a slicing stroke.

A qualitative measure of the amount of trauma can be judged by the individual, based on the stinging effect of strong alcoholic lotions (70 per cent by volume).

There are some conflicting precautions in the description of the shaving mechanism, so that one can hardly expect to experience a maximum of closeness, the freedom from pulling discomfort, and a freedom from trauma all in the same shave.

One precaution, however, is common to all these items—**softening of the beard.** This cannot be stressed too strongly, as failure to observe it produces incomplete and uncomfortable shaves, leaves the skin with many abrasions which are invitations to infection, and may even ruin razor blades.

Softening of the beard is accomplished by wetting the hair, which in its normal dry state is a hard material. This change is best effected by the use of soap. The mechanism by which soap causes hair softening will be discussed in the following section.

SHAVING SOAP COMPOSITION AND CHEMISTRY

A soap may be defined chemically as a metal salt of one of the higher fatty acids. Since insoluble soaps are not useful for detergent purposes, only the sodium and potassium salts are used in commercial soaps. In more recent years the soaps of the stronger organic bases, principally triethanolamine, have been added. The widely available fatty acids that are useful are luric, myristic, palmitic, and stearic of the saturated series, and oleic and linoleic of the unsaturated series. Commercial soaps are mixtures of several of the eighteen possible combinations of the three bases and the six acids, together with water in varying amounts and other materials that may have specific uses, as well as small quantities of the soaps of other acids.

Shaving soaps are sold in various forms and shapes such as the old-fashioned bar, the shaving stick, the wooden mug, the shaving powder, the lather-type shaving cream, and the so-called brushless shaving cream. Essentially there are but three varieties: The first four are all examples of hard shaving soaps; then there is the cream type of shaving soap, which is a soft soap containing an abundance of water and, frequently, air; and, lastly, the so-called brushless shaving cream. The latter two are most popular with the self-shaver.

The harder forms, such as those sold in powder or stick or cake, are somewhat similar to toilet soaps in composition, but the softer forms sold as "shaving creams" in tube or jar contain a larger proportion of potassium soap and also a larger proportion of water.

In general, the acid constituents are derived commercially from three classes of oil; namely, the "tallow class," the "nut oil" class, and the olive oil class. The tallow class, which supplies mainly palmitic, stearic and oleic acid, includes tallow and palm oil. The nut oil class, which supplies principally lauric and myristic acid, includes coconut oil, palm kernel oil, and babassu oil. The olive oil class, which supplies mainly oleic acid, includes olive oil, olive oil foots, and similar soft fats.

We do not list exact shaving soap analyses. There may be eighteen or more distinct soaps present in a commercial product. Analytical procedures for separating and determining them individually are difficult and tedious. Because of these difficulties such analyses are rarely made and published.[5] Instead, it is common practice, as in the case of the American Society for Testing Materials,[7] to report all the soaps present merely as "anhydrous soap" and to measure the amount of unsaturated acid derivatives present by an "iodine number."

Since the laurate and myristate soaps have irritating effects, the use of analytic methods will serve an excellent purpose, by determining the approximate proportion of these irritating constituents for every brand of shaving soap. The saponification value does this.

In the absence of figures for the final composition of shaving soaps some formulae[8] can be given for their manufacturing constituents. These formulae follow:

Bar Soap

Tallow	180 parts
Coconut oil (Cochin type)	108 parts
Stearic acid (double pressed)	207 parts
Soda lye 40° B (35½% NaOH by weight)	132 parts
Potash lye 38° B (36½% KOH by weight)	108 parts
or	
Coconut oil	300 parts
Soda lye 35° B (29½% NaOH by weight)	40 parts
Potash lye 50° B (50% KOH by weight)	550 parts
Glycerin C.P.	80 parts
Stearic acid	1050 parts

Lather Shaving Cream

Within recent years a softer form of shaving soap, which we term shaving cream, has been developed. This is similar to the hard type of shaving soap except that it contains larger portions of potassium soap, water, and air. The following formula is characteristic of this class:

Coconut oil (Cochin type)	100 parts
Tallow (refined) in olive oil	100 parts
Glycerin	150 parts
Soda lye 20° B (14½% NaOH by weight)	200 parts
Potash lye 20° B (17% KOH by weight)	1005 parts
Water	550 parts
Stearic acid (double pressed)	825 parts
Boric acid	30 parts
Perfume	15 parts

Brushless Shaving Creams

Brushless shaving creams are in a class entirely apart from shaving soaps, differing in action and in proportion of constituents, published statements to the contrary. Whereas shaving soaps contain either no free fatty acid or else only a small quantity, the brushless creams contain uncombined fatty acid in substantial proportion. In their manufacture the fatty acids themselves are used instead of their commercial sources, the oils and fats, so that their composition is under better manufacturing control. As a rule the acid used is the best grade of stearic (commercially nearly half palmitic acid), and the irritating lauric and myristic acids are not present except as very slight impurities in the commercial supplies. A large quantity of water is also present, usually 65 to 75 per cent of the whole. Other constituents may be spermaceti to prevent too rapid absorption into the skin, lubricants including many oils, glycerin to prevent too rapid evaporation, and some wetting agents. The alkalies may include soda, potash, and triethanolamine, all in the same cream.

These creams do not produce much lather and are not intended to be used with a brush. Instead they are rubbed on the skin surface with the fingers. Suitable consistency for this purpose is an important requirement of the class. Published formulae for brushless creams follow:

Stearic acid	52 parts
White mineral oil	7 parts
Distilled water	250 parts
Potash lye 36° B (34% KOH by weight)	6 parts
Glycerin	12 parts
Perfume	1 part

or

Stearic acid (triple pressed)	39 parts
Mineral oil	5 parts
Glycerin	9 parts
Triethanolamine	1 part
Water	180 parts
Perfume	1 part

An investigational analysis of many published compositions of brushless shaving creams shows that they may be summarized in terms of the ratio of other constituents to the quantity of stearic (stearic plus palmitic) acid. These ratios follow:[8]

Stearic acid	1.0
Water	3.0 to 5.0
Alkali (sodium hydroxide, borax, potassium hydroxide, triethanolamine)	0.02 to 0.2
Other materials (glycerin, mineral oil, lanolin, carbitol, glycol stearate, spermaceti, sodium lauryl sulphate, etc.)	0.2 to 0.7

(Departure from the limits of these proportions governs whether the product becomes a vanishing cream, a cleansing cream, or a cold cream.)

THE PURPOSES OF THE USE OF SOAP FOR SHAVING

The purposes of the use of soap for shaving are complex. Heretofore these were considered as the following:

1. Wetting and softening.
2. Lubrication.
3. Antisepsis.

However, in view of more recent observations, the following classification is more acceptable:

1. Acceleration of softening and wetting and alteration of the final degree of softening of the hair shaft.
2. Mechanical surface layer protection.
3. Antisepsis.
4. Removal of gritty particles.

1. Acceleration of Softening and Wetting and Alteration of the Final Degree of Softening

It has been pointed out in previous paragraphs relating to the mechanism of shaving that softening of the hair is not only desirable but is almost an absolute requirement for daily shaving if unnecessary damage to skin and razor blade alike are to be avoided. This process, the time for which is suitably described as a preparational period, has been traditionally carried out with soap lather. Experimental investigation has indicated good reasons for this choice by civilized man.

Hair in its normal dry state is as hard as some of the softer metals. This is too hard for easy shaving and it requires wetting and softening. This can be accomplished by water alone; for this purpose soap is not essential. However, the rapidity with which water absorption takes place is greatly influenced by soap lather and the proper method of its application.

Thus, the function of soap can be stated as an **accelerator of softening and wetting**, and as an **alterant of the final degree of softening.**

Actual clinical observations have shown that the fastest and most satisfactory method to obtain proper hair softening and wetting is as follows:

1. Either ordinary or shaving soap is rubbed into the skin, using hot water (about 120° F.) and considerable movement with hands, wash cloth, or shaving brush.
2. This lather is rinsed off completely with hot water.
3. One's favorite soap, shaving cream, or brushless cream is applied.

The importance of using water as hot as can be borne comfortably (as above stated, at about 120° F.) and the lapse of at least three minutes before the use of the razor, cannot be too strongly emphasized. Failure to follow the above procedure is responsible for more unsatisfactory shaves than is any other single item connected with shaving.

In order further to determine the conditions needed to produce the optimum amount of hair softening and wetting, the following experiments were devised and carried out by Casselman: [4]

The time required to soften hair by aqueous solutions was studied by a method based on the rate of elongation of single hair samples when stressed with 16 kilograms per square millimeter of load, being immersed in a test liquid. This amount of load does not stretch hair appreciably in its dry state, but when the hair is fully saturated with water it produces a stretch up to 50 per cent of its original length. Thus the hair is stretching while it is softening. For this test 25 centimeter long scalp hairs were used, having a diameter of from 0.055 to 0.063 millimeters. The amount of stretch was measured during time intervals up to half an hour. Recently Casselman improved this test by taking motion picture photographs of the stretched hair at measured intervals.[3]

These tests were carried out at various temperatures and in various liquids. It was found that hot water and soap solution gave the quickest and most satisfactory results. This is shown in Table 3.

Kish [9] confirmed independently the observations that

1. Alkaline solutions soften hair more rapidly than water.
2. Hot solutions soften hair more rapidly than cold solutions.
3. Hair that is first freed from sebaceous material is softened more rapidly than untreated hair.

Many of these observations can be explained on obvious physical or chemical grounds related to

1. The changes and the effects of surface tension in liquids.
2. Effects of temperature on chemical reaction rates.
3. The hair-softening process itself.

Changes and Effects of Surface Tension. The reactions between surfaces and liquids are complicated by surface tension effects. A liquid surface is somewhat like a thin rubber balloon. It tries to contract and we say it is under tension. This tension, which in the case of liquid is surface tension, is ordinarily measured in units of force per unit of length. The units that are appropriate to most liquids are dynes per centimeter. In the case of pure water the surface tension is approximately 72 dynes per centimeter. Water that contains "wetting agents," of which soap is a good example, may have a surface tension less than half this value.

TABLE 3

RELATION BETWEEN TIME OF IMMERSION AND STRETCH OF SINGLE LOADED HAIRS

	Fraction of Full Stretch Observed					
Condition	*20 sec.*	*40 sec.*	*60 sec.*	*80 sec.*	*100 sec.*	*150 sec.*
Tests with plain water						
Dark hair, 120° F.	0.70	0.86	...	...	...	...
White hair, 120° F.	0.70	0.86	...	...	...	...
Dark hair, 86° F.	0.58	0.84	0.95	...	...	...
White hair, 84° F.	0.10	0.35	0.66	0.82	0.93	...
Dark hair, 62° F.	0.02	0.08	0.18	0.35	0.60	0.95
White hair, 57° F.	0.02	0.08	0.15	0.25	0.43	0.88
Tests with saturated soap solution at 75° F.						
Dark hair	0.50	0.90	...	...	...	...
Dark hair	0.38	0.82	0.92	...	...	...
White hair	0.11	0.51	0.85	0.95	...	...
White hair	0.09	0.10	0.77	0.91	...	...
White hair	0.08	0.33	0.67	0.87	...	...

Surface tension is related to wetting properties of the liquid. Plain water which has a high surface tension does not wet greasy surfaces, nor does it penetrate greasy tubules, such as hair may have or may be. Reduction of the surface tension by means of soap or other wetting agents makes possible both the wetting of the greasy hair and the penetration of the tubules themselves. The same mechanism also explains in part the detergent action of soap, interpreting how rubbing movements actually emulsify the grease on a surface and how they help to remove it. Thus the "rubbing in" of lather removes one of the barriers to the penetration of water into the hair shaft.

Effects of Temperature. There is nothing surprising in the observation that hair softening rates are rapidly increased by using hot water instead of cold water. It is common to expect chemical reactions to increase in rate as the temperature is raised. Furthermore, there is a possibility that the melting point of the sebaceous grease film may be exceeded by hot water of 120° F. or so, making its emulsification easier.

The Hair-softening Process. The chemical composition of hair has been shown to be chiefly keratin. Keratin is insoluble in water but absorbs it readily up to a maximum of 33 per cent of the original dry weight, losing considerable strength and hardness in the process. The presence of weak alkali is conducive to the absorption of more than 33 per cent water. Strong alkalies dissolve keratin completely. It is reasonable therefore to expect alkaline soap lather to make hair softer than does plain water. However, the amount of free alkali necessary to dissolve keratin would be seriously irritating to the skin.

2. MECHANICAL SURFACE LAYER PROTECTION

An abundant creamy lather acts as a mechanical surface layer protector and also as an indicator that the planing operation is being carried out thoroughly. This function could be obtained by the use of any soft vehicle. This is frequently spoken of as lubrication, which it is only if this term is understood as the separation of two sliding solid surfaces by a viscous liquid.

3. ANTISEPSIS

We need to spend little time on the antiseptic value of soap in this particular connection. Authoritative reports[10, 11] give ample evidence of its value as a bactericidal agent, against certain bacteria only. Walker[11] stated that soaps are not germicidal against typhoid bacilli and staphylococci. Of these, the staphylococcus is of great importance in relation to shaving because it is frequently present on the skin and is frequently the causative agent of impetigo contagiosa.

It must be remembered also that there are other types of infection which are not made innocuous as the result of the action of soap. These belong in the group of deeper mycelial infections such as blastomycosis, actinomycosis, and tinea profunda.

There is, however, one important consideration which we have failed to find in literature but which has struck us very forcibly. This has to do with the primary lesion, the chancre, of syphilis. Among a good number of patients with extragenital chancres, we have had experience with only one individual who presented a chancre over the bearded area of the face, and in this instance the patient, who was a self-shaver, used to shave frequently without the use of soap, using razors other than his own. There is not much question that under certain unhygienic conditions barbers' knives or friends' razors may have at times become infected with blood carrying *Treponema pallidum.* The extreme rarity of transference of syphilis in this manner is another clinical evidence of the antiseptic value of soap.

4. Removal of Gritty Particles

Rough hard particles of compact consistency are part of the extraneous material which may collect on the exposed skin surfaces. The chief difficulty which they occasion is to the edge of the razor blade, and therefore a thorough rinsing of the face after soaping is essential to get rid of these particles effectively.

REQUIREMENTS OF A GOOD SOAP FOR SHAVING[7, 12]

1. The lather produced should be heavy, creamy, and not gummy, which properties should be obtained with as little lauric and myristic acid derivative as possible.
2. The lather should remain moist on the face until shaving is completed.
3. The soap itself must be more soluble than ordinary toilet soaps.
4. It must have good detergent properties, which means that it removes grease because it reduces the surface tension of the soapy liquid and is a powerful emulsifying agent.

Requirements of a soap for shaving, except as above described, are chiefly matters of personal taste and convenience and are listed as such.

mum of 33 per cent of the original dry weight, losing considerable strength and hardness in the process. The presence of weak alkali is conducive to the absorption of more than 33 per cent water. Strong alkalies dissolve keratin completely. It is reasonable therefore to expect alkaline soap lather to make hair softer than does plain water. However, the amount of free alkali necessary to dissolve keratin would be seriously irritating to the skin.

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Requirements of a soap for shaving, except as above described, are chiefly matters of personal taste and convenience and are listed as such.

In addition to these, requirements for a good shaving cream are as follows:

1. The cream should remain soft yet firm and it should distribute well into the bristles of the shaving brush.
2. It should adhere to the face.
3. It should be a cream, not a dough.
4. A small quantity should be able to produce enough lather to cover the face, again recognizing the laurate and myristate limitations.
5. It should rinse readily from the razor.
6. It must not attack the collapsible tube or corrode the clips at its open end.

The desirable properties of a brushless shaving cream may be summarized as follows:

1. It should be able to soften the hair.
2. The cream must not be too thin.
3. It must spread easily.
4. It must remain damp during the shaving process.
5. It must remain soft in the tubes which contain it.
6. It must rinse readily from the razor.

HARMFUL EFFECTS OF SOAP

Harmful effects of soap can be classified under four headings:

1. Soaps may cause irritation.
2. They may cause sensitization.
3. They may cause disturbances through improper use, really not the fault of the soap.
4. They may have a harmful effect on the razor blades or on the containers within which they are placed at the disposal of the self-shaver.

1. Irritation

Irritation is recognized by both subjective and objective symptoms. Subjective symptoms are the more frequent ones, and manifest themselves in pricking, burning, smarting, uncomfortable feeling, the feeling of tightness, or a drawn sensation during the use of the soap for shaving or shortly after the soap has been washed off. Frequently this irritation is associated with a blush or redness which is easily discernible but which disappears in a short period of time, from 10 to 15 or 20 minutes. This latter is spoken of as the objective symptom.

At times the irritation becomes severe enough to produce an actual chemical dermatitis, in which case the previously mentioned subjective symptoms are much more exaggerated and the objective symptom of redness becomes associated with scaling of the epidermis and a more persistent form of inflammation or dermatitis which lasts over periods of days. When and if the soap is reapplied without the lapse of sufficient time, the symptomatology increases in acuity, as far as both the subjective and the objective symptoms are concerned. As a matter of fact, this may reach such proportions that it will cause pain and discomfort. To this the swelling of the soft tissues adds its annoying presence.

Irritation is defined as a phenomenon which may occur in the greater proportion of individuals when exposed to a chemical substance of a reasonable degree of dilution. The direct effect of soap as an irritant can be readily ascertained by the area of involvement, the time of its occurrence, and other relationships demonstrable between soap applications and the development of the skin inflammation. One must not confuse it with irritation the result of other forces such as friction, wind, sun, cold, etc., all of which might produce similar types of skin disturbances.

It has been our experience that the application of strong alcoholic lotions after shaving forms the basis for a test, by which test one may determine whether an irritation is mechanical or chemical. In the absence of a chemical irritation of the skin, stinging and burning sensations should disappear within 15 minutes of the application of strong alcoholic lotions, and one can be sure that whatever irritation is present has been caused only by the mechanical trauma of the passage of the razor blade. On the other hand, if burning and stinging sensations persist, then the shaving process is not to be blamed as the cause, but rather irritation by specific soap molecules. Principally laurate and myristate soaps are to be considered as the offending agents.[6, 13, 14] No soap is entirely free of these two soap molecules.

The brushless creams, on the other hand, in most cases are essentially free from these irritating agents.

2. SENSITIZATION

Harmful effects may arise from the fact that an individual may be sensitive to the constituent parts of soap itself. This is especially true, for instance, of such substances as coconut oil. Of course, sensitization may be the result of an allergic phenomenon to any of the component parts of soap itself. Just what causes this apparently overt act of the skin, this excessive reaction which manifests itself in appearing as a form of skin inflammation or dermatitis, is the subject of a great deal of discussion and theorizing, all of which leads to the observation that certain substances which otherwise are harmless arouse the four cardinal characteristics of inflammation—pain, heat, redness, and swelling—in a certain small group of individuals, variously estimated as from 1 per cent to 15 per cent of our population, and placed as a phenomenon of allergy. The percentage of population allergic to soap is exceedingly small.

The best definition for allergy is an abnormal reaction to a specific sensitizing agent. A sensitivity such as this usually increases in its severity to such an extent that permanent changes will occur on the skin of the face. This pliable structure will become thickened, reddened, nodule or papule covered, itchy, burning, and unsightly. Relief is sought by scratching and otherwise damaging the skin, and a secondary infective dermatitis may arise, thus complicating the picture of sensitivity with the picture of secondary skin infection.

Sensitivity to soaps has been frequently ascribed to the alkalies which they contain, many investigations to the contrary, although it must be said that the favorite form of investigation, so-called patch testing, is anything but a satisfactory method of determination for sensitivity. In a series in which 600 individuals were tested, a 2 per cent soap solution was applied in the form of a patch test. This solution acted as a primary irritant in 124 of the 600 individuals. In the repatch testing on the previously tested area, 130 of the 600 individuals reacted, a much greater percentage than one would find by any other type of investigation for sensitivity. Such a high percentage of sensitization is very unlikely, and this method of investigation for this particular purpose will have to be amended in some fashion. It is apparently a test of irritation rather than a test of sensitivity.

Sufficient has been learned, however, that the harmful effects of soap for shaving, which manifest themselves by stinging and burning, by an uncomfortable feeling during the preparational period, during the actual shaving period, and for much longer than the usual time after shaving—sometimes extending over the greater part of the twenty-four hours and in more serious cases continuing and developing into an actual and persistent dermatitis—can be reduced by the elimination not of soap itself but of the sodium laurate and salts of myristic acid in the preparation of soap for shaving, of which, as we stated before, the group of brushless shaving creams may be an excellent example.

Individuals vary widely in their capacity to be irritated by soap. At one extreme is the individual who cannot so much as wash his unabraded skin with an all-coconut-oil soap without observing reactions of a disagreeable type. At the other extreme are men who cannot only wash but who can prepare their faces and shave with an all-coconut-oil soap without experiencing the slightest reaction.

In the case of these extremely sensitive individuals, who also react to lauric acid derivatives that are present in most soaps, we have found a shaving technic that appears to keep their skins free from uncomfortable sensation and irritation.[3] This technic requires the use of cold water throughout the whole shaving process and a frank facing of the fact that it is going to take a longer preparational period because of the use of cold water. The beard is first softened by lathering with an all-tallow soap, which after rubbing for at least two minutes is rinsed off, all with cold water. Another period of two to three minutes is then used to apply a brushless cream of the ordinary type. Shaving is begun by wetting the razor with cold water, and only cold water is used at any time, even for rinsing the face afterward. When these sensitive persons apply the alcohol lotion test described above, they find that the stinging sensation disappears in the short time that is common to all nonsensitive shavers. Furthermore, their general skin condition improves markedly.

3. Improper Use of Soap

Improper use of soap may cause harmful effects. As it has been pointed out, the primary purpose of soap in shaving is its hair-wetting and hair-softening abilities, and as it has also been pointed out, this requires a certain amount of time which we choose to call the preparational shaving period. If sufficient time is not permitted to elapse for the soap to penetrate through the sebaceous-secretion-covered hair and to penetrate the hair shaft itself, the job of the razor blade is greatly handicapped, and thus trauma may result, which can be averted only if soap is properly used in the preparational period.

The effect of soap on the traumatized shaving field cannot be evaluated. It would seem that wherever a deeper injury has been produced soap may act as a chemical irritant. However, this is most likely not true for several reasons:

1. Soap is actually removed from the area at the time the injury is produced.
2. Where a deeper injury exists, the flow of blood washes away any soap which may have been left.

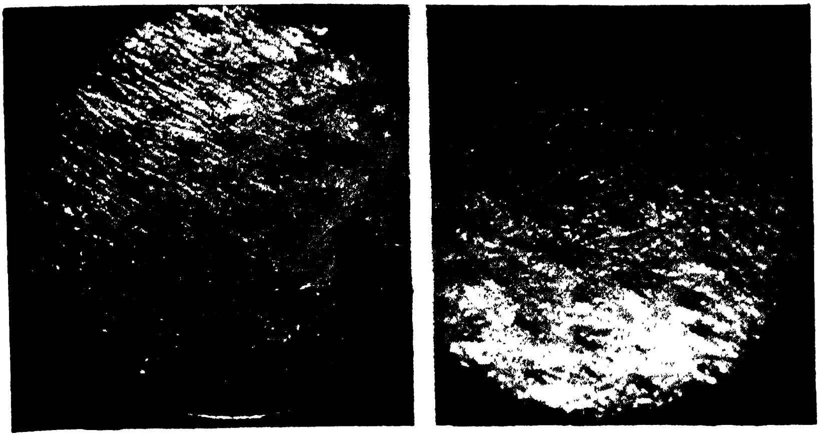


FIG. 25. Direct view of skin showing twenty-four hour growth of beard. Magnification 8×.

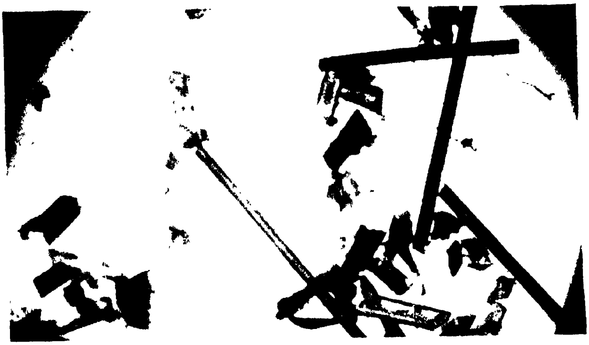
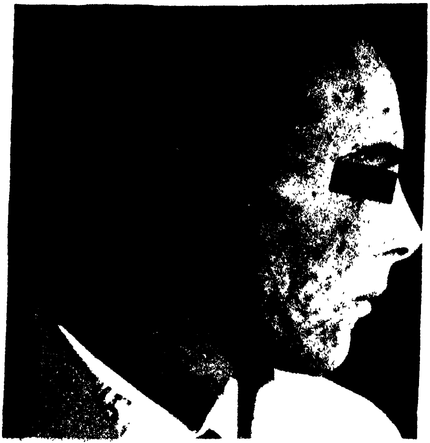
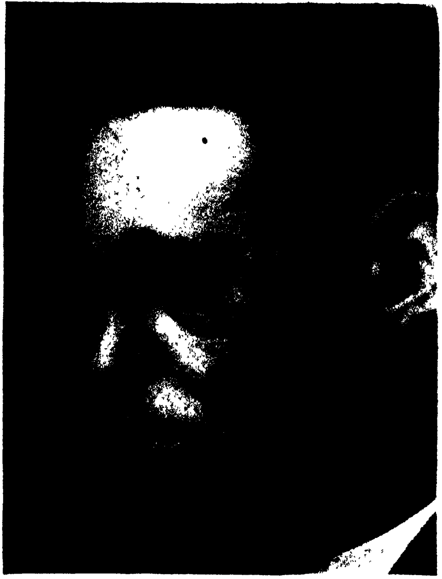


FIG. 26. Skin and hair chips from shaving mixed with scalp hair for comparison. The long, thin hairs are scalp hairs. The short, thick hairs are beard hairs. Other particles are skin chips. Magnification 20×.

FIG. 27. Electric shavers cause ablation damage also as shown by skin chips collected. Magnification 30×.

FIG. 28.





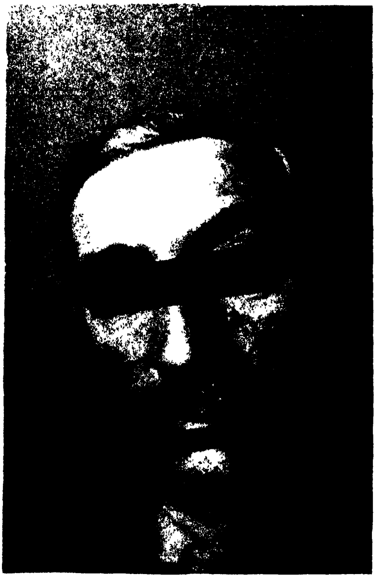


FIG. 29.

FIG. 30.

FIG. 28. Acne vulgaris, a frequent disease of the skin, chiefly during adolescence. Patients should avoid shaving when pustules are numerous.

FIG. 29. Recurrent herpes simplex, the so-called fever blisters or cold sores. The easily rupturing pin-point blisters cover a painfully sensitive skin. Avoid shaving during the seven to ten days while the attack lasts.

FIG. 30. Tinea sycosis, a deep-seated follicular infection caused by a fungus. Avoid shaving during the attack.

FIG. 31.

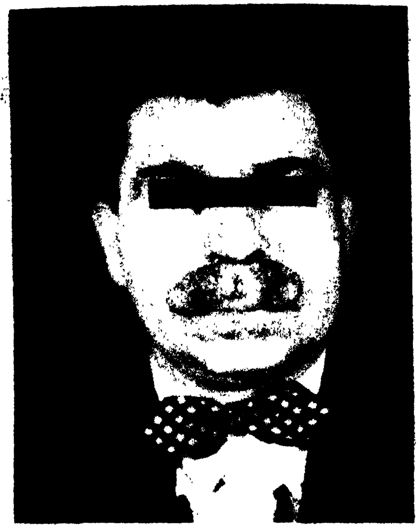
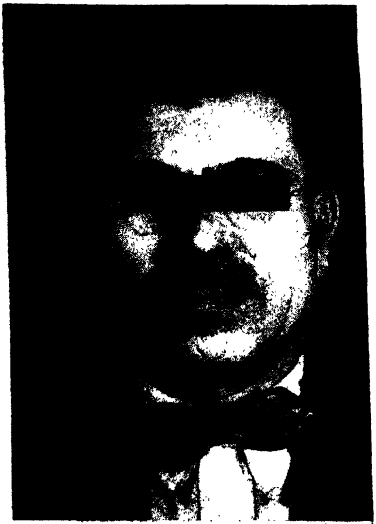


FIG. 32.



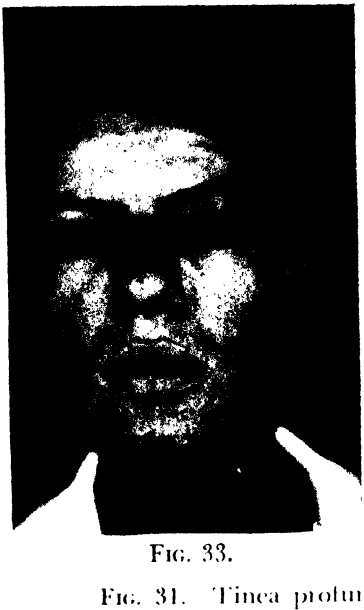


FIG. 33.

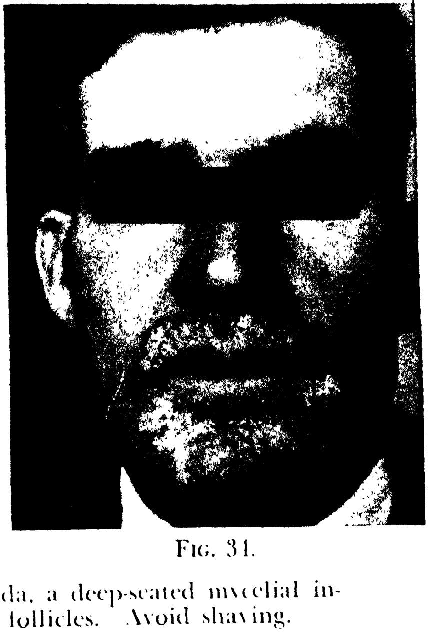


FIG. 34.

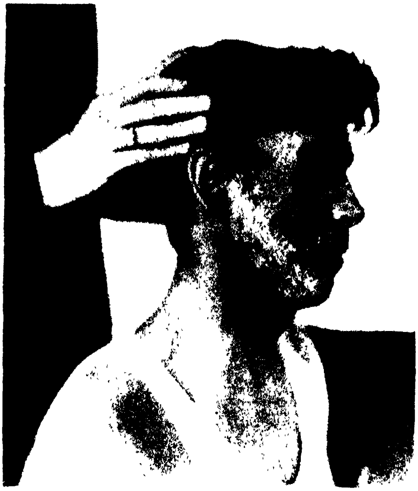
FIG. 31. Tinea profunda, a deep-seated mycelial infection of the hair follicles. Avoid shaving.

FIG. 32. Tinea profunda, after four weeks of treatment with x-ray and iodides.

FIG. 33. Sycosis vulgaris, a chronic and recalcitrant disease of the hair follicles, usually affecting only the bearded area. Avoid the trauma of shaving.

FIG. 34. Sycosis vulgaris.

FIG. 35.



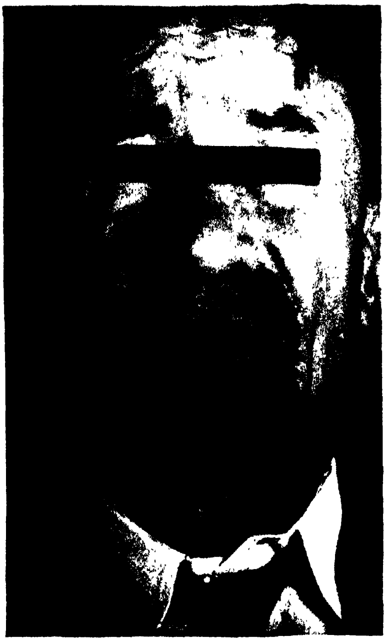


FIG. 36.

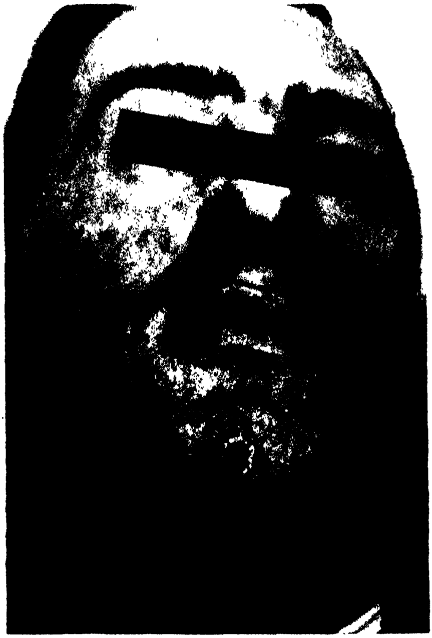


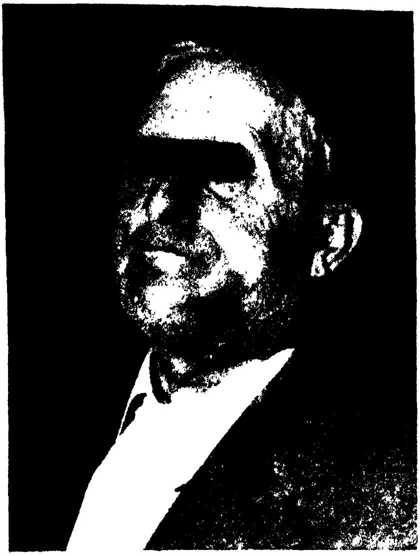
FIG. 37.

FIG. 35. Sycosis vulgaris.

FIG. 36. Acute exacerbation of sycosis vulgaris.

FIG. 37. Syphilis—a chancre, the primary lesion of syphilis, on the bearded area. Patient used no soap for shaving.

FIG. 38.



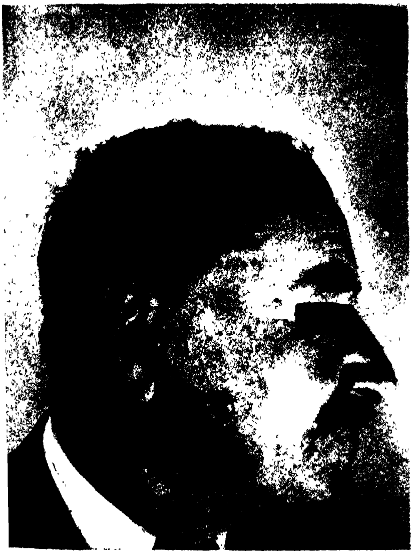


FIG. 39.

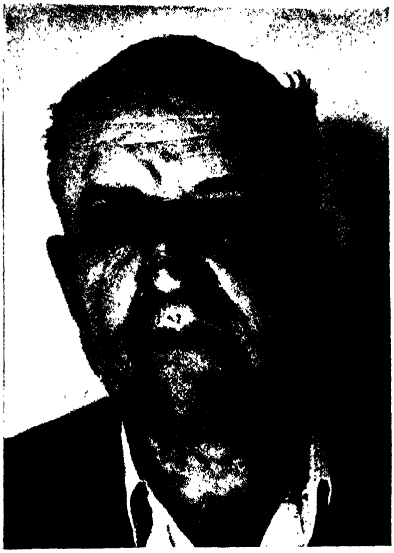


FIG. 40.

FIG. 38. Actinomycosis, a lumpy jaw, caused by the "ray fungus" and secondary to underlying disease of bone and periosteum of the lower jaw. The infection is introduced through carious teeth. Avoid shaving.

FIG. 39. Carcinoma of the skin. Shaving traumatizes this new growth and may affect it adversely.

FIG. 40. Carcinoma of the skin.

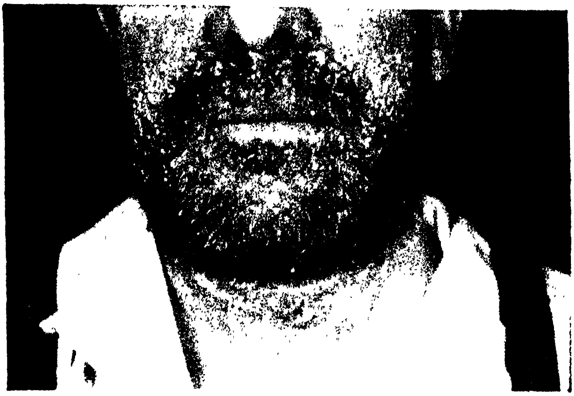


FIG. 11. Impetigo contagiosa, a highly infectious skin disease in which shaving should be avoided.

3. The clotting of blood itself would prevent the contact of soap with the deeper tissues.

However, in individuals in whom irritation or sensitization from soap occurs, these are magnified over the somewhat denuded epithelial surfaces.

4. Harmful Effects on Razor Blades[3]

Ordinarily, soaps do not have damaging effects on the razor blades. This is not true of the brushless creams, and this difference is due to the fact that brushless creams differ from soap in their degree of alkalinity. Soaps have an alkalinity which is technically measured as pH value of roughly 10.0. On the other hand, the pH of brushless cream is roughly 7.0.

It has been both our own observation and that of others that brushless creams with their lower pH values dull razor blades more quickly than do soaps which have a higher pH value. This dulling is occasioned by chemical and electrochemical action during the shaving process. In an experiment to demonstrate the exaggeration of this point, Casselman produced a brushless shaving cream having a pH value of 6.0 by mixing with the brushless shaving cream a solution of sodium acid phosphate. He could find no razor blade of any make that would remain sharp throughout a single shave when the face was lathered with this particular brushless cream.

LEG AND AXILLARY SHAVING

Within recent times two other large groups of shavers have been added to the group of men whom we have considered.

One group consists of both women and men who shave their axillary hairs, usually once a fortnight, for its deodorant and cosmetic effect. This group includes such professional people as theatrical performers, etc.

The other group consists of women who shave their legs.

Leg make-up is an adherent, rapidly drying tan pigment-containing cream which is applied directly to the bare skin and gives the appearance of hose. The successful use of this so-called leg make-up is predicated on the preliminary removal of hair.

Sparsity of hair in both locations, the comparative infrequency of shaving required, the smaller diameter of the hair under consideration, and the relatively firm base of the skin surface over the legs as well as the relatively more even contour in the same location make the procedure of shaving in these areas simpler and easier. However, in order to reduce the pulling effect on the hairs and to reduce the trauma to skin surfaces it is strongly recommended that these areas be properly prepared for shaving in the manner described for shaving of the bearded area.

THERAPEUTIC SHAVING

Shaving is also carried out as part of preparational technic in the realm of surgery and therapeusis:

1. To obtain the greatest possible freedom from harmful bacteria on the skin surfaces, the so-called field of operation is shaved, whether the operation be major or minor.

2. Wherever adhesive plaster is to be attached for the purpose of dressing retention, the hair is shaved to facilitate its later removal and to lessen the otherwise greater discomfort during removal.

3. The proper preparation for the application of plaster-of-Paris casts, the so-called gelatin boots, or any occlusive dressings which have to be kept in place for a relatively longer period of time includes shaving of the part.

4. Scalp and pubic lice attach their ova to the extrafollicular portion of the hair shaft, and thus the hair becomes the hatching stem of these obnoxious and pestiferous parasites. Eradication of them must include the destruction of the nits, which are the ova from which the young ones are hatched. Although other methods are available, shaving

furnishes the quickest method of eradication and is recommended for this purpose.

5. At times, in order to be able to visualize the extent of involvement of the scalp in certain types of infections such as pyoderma or in such affections as atopic or contact dermatitis, shaving of the scalp is recommended, especially when the application of some derivative of tar is to be used over any hairy surface.

Proper preparation of these fields for shaving includes the thorough use of soap, both as an antiseptic measure and to reduce any inconvenience or discomfort caused by shaving.

THE USE OF SOAP FOR SHAVING IN THE PRESENCE OF COMMON SKIN DISEASES

There are a number of skin diseases which occur on the face with sufficiently great frequency that they deserve special mention as to the manner in which they affect the use of soap for shaving. They include such common and simple skin diseases as acne vulgaris, herpes simplex, impetigo contagiosa, sycosis vulgaris, keratosis pilaris, and carcinoma of the skin of the face.

Acne Vulgaris

This is a disorder of the minute sebaceous glands of the skin, usually beginning at puberty and continuing, during the adolescent period, well into early adulthood. This condition is frequently called by its most predominant objective symptom, "pimples." These small lesions are usually pus-containing little elevations which appear amid blackheads and other minor nodules over the surface of the face, including, of course, the beard-bearing area. It is of particular concern to us in this consideration that boys and young men suffer the more severe attacks of acne vulgaris.

Under ordinary conditions the use of soap for shaving is not contraindicated. However, when the so-called pustules, the yellow-topped debris-containing softened little lumps, are predominant, shaving causes mechanical abrasions to the roof of these pustules and causes pain and discomfort. Also, if the pustules contain pyogenic organisms unaffected by soap solution, these may be transferred by the act of shaving. Therefore, the use of soap for shaving in acne vulgaris depends on the above stated conditions.

Herpes Simplex, or Cold Blisters, or Fever Blisters

This is a notoriously recurrent form of blistery eruption, which becomes a bothersome condition in certain afflicted individuals, chiefly because of the smarting, burning, and pain which it produces, and also because it is unsightly and because it recurs supposedly following even slight rises in body temperature or some type of gastrointestinal upset, although in susceptible individuals any cause might suffice. The eruption is composed of an area of redness upon which a fine tissue paper-thin blistery eruption arises. The slightest abrasion will cause the puncture of these minute blisters and a gummy encrustation will replace them. This, depending on whether it becomes infected or not, maintains or changes its character. The entire condition lasts from seven to ten days. The area surrounding the upper or lower lips is the most frequent site of occurrence.

The application of soap and the operation of shaving cause pain, discomfort, and tend to prolong the attack by both chemical and mechanical irritation. It is best to avoid shaving the area during the attack. It is noteworthy that the growth of hair itself is noticeably decreased in the affected area during the period of the attack.

Impetigo Contagiosa

This is a highly infectious disease of the uppermost epidermal layers of the skin. Although it is associated with the idea that it occurs only in children to such an extent that a good many of the laity refer to it as "infantigo," this dis-case may affect any individual. It is caused by the ordinary pus-producing germs found on the skin, the so-called streptococci and staphylococci. It seems that these germs cannot penetrate the epidermis, and that damage of sufficient severity to penetrate through the horny layer of the epidermis is essential in the causation of impetigo. Such damage, of course, is amply provided by the nicks and cuts of shaving.

In view of the ubiquitous nature of the pus-producing organisms previously referred to and of the type of damage produced daily by shaving, the infrequency of impetigo contagiosa on the faces of shavers attests to the antiseptic qualities of soap used for shaving. However, as pointed out before, certain types of staphylococci are unaffected by ordinary soap solutions. These then, if present in sufficient numbers, may give rise to the formation of impetigo contagiosa, and when this occurs continued application of soap and shaving can only lead to magnification of the trouble. Therefore, it is recommended that during attacks of impetigo contagiosa the individual should discontinue the operation of shaving. It may be important to mention that all the utensils used for shaving be thoroughly disinfected, preferably by boiling, before the practice of shaving is resumed if these articles were used during the primary phases of the development of impetigo contagiosa.

Sycosis Vulgaris, or the So-called Barber's Itch

This is essentially a suppurative infective inflammation of the hair follicles. The ordinary pus-producing organisms, the staphylococci and the streptococci, pick out the site of the origin of the hair shaft and become so firmly implanted that a chronic, protracted, disfiguring, and highly annoying skin disease results. The pathognomonic or distinctive symptom is a yellow-topped pustule, the center of which is pierced by a hair shaft. It must be reemphasized that this notoriously recalcitrant skin disease causes distinct hardship, perhaps for years, to the individual who is afflicted by it.

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The application of soap and the operation of shaving cause pain, discomfort, and tend to prolong the attack by both chemical and mechanical irritation. It is best to avoid shaving the area during the attack. It is noteworthy that the growth of hair itself is noticeably decreased in the affected area during the period of the attack.

IMPETIGO CONTAGIOSA

This is a highly infectious disease of the uppermost epidermal layers of the skin. Although it is associated with the idea that it occurs only in children to such an extent that a good many of the laity refer to it as "infantigo," this disease may affect any individual. It is caused by the ordinary pus-producing germs found on the skin, the so-called streptococci and staphylococci. It seems that these germs cannot penetrate the epidermis, and that damage of sufficient severity to penetrate through the horny layer of the epidermis is essential in the causation of impetigo. Such damage, of course, is amply provided by the nicks and cuts of shaving.

In view of the ubiquitous nature of the pus-producing organisms previously referred to and of the type of damage produced daily by shaving, the infrequency of impetigo contagiosa on the faces of shavers attests to the antiseptic qualities of soap used for shaving. However, as pointed out before, certain types of staphylococci are unaffected by ordinary soap solutions. These then, if present in sufficient numbers, may give rise to the formation of impetigo contagiosa, and when this occurs continued application of soap and shaving can only lead to magnification of the trouble. Therefore, it is recommended that during attacks of impetigo contagiosa the individual should discontinue the operation of shaving. It may be important to mention that all the utensils used for shaving be thoroughly disinfected, preferably by boiling, before the practice of shaving is resumed if these articles were used during the primary phases of the development of impetigo contagiosa.

Sycosis Vulgaris, or the So-called Barber's Itch

This is essentially a suppurative infective inflammation of the hair follicles. The ordinary pus-producing organisms, the staphylococci and the streptococci, pick out the site of the origin of the hair shaft and become so firmly implanted that a chronic, protracted, disfiguring, and highly annoying skin disease results. The pathognomonic or distinctive symptom is a yellow-topped pustule, the center of which is pierced by a hair shaft. It must be reemphasized that this notoriously recalcitrant skin disease causes distinct hardship, perhaps for years, to the individual who is afflicted by it.

Although it is called a barber's itch, in our experience it is much more frequent in the self-shaver than in the barber-shaved individual. This is attributed by us to the professional barber's time-worn practice of a long preparational period before shaving.

When sycosis vulgaris once becomes established, the use of soap and the ordinary type of shaving are to be discontinued, not only because of the pain and discomfort they produce, but because they tend to spread the infective folliculitis through the nicks and cuts and also because these mechanical abrasions interfere with the repair processes invoked by the skin to counteract this folliculitis. Recently the chronicity of the condition has been beneficially influenced by the use of an ointment which changes the flora of the skin sufficiently to discourage the multiplication and growth of the offending bacterial organisms. The electric type of shaving is advantageous during the actual attacks.

KERATOSIS PILARIS AND INGROWN HAIRS

Ingrown hairs are the bane of existence of certain soft, thin-skinned individuals whose beard is usually black, hard, and heavy. As previously pointed out, this condition has to do with the variability of the angle of the emergence of the hair shaft from the skin. In those instances in which the acuteness of the angle of hair emergence becomes grossly exaggerated, the hair shaft, instead of emerging through the epidermis, may push itself between the uppermost layers (stratum corneum and stratum granulosum) of the epidermis. When the hair shaft embeds itself in this horny layer-covered channel, it actually becomes a foreign body and acts in a like manner. It causes discomfort, jagging pain, redness of variable degrees, and after a certain length of time pus develops—all the symptoms that a splinter or a thorn is capable of causing.

Trauma of the skin is frequently a predisposing factor in keratosis pilaris.[8] In such instances, it is our belief that the chemical trauma caused by the soap, not the mechanical trauma caused by the shaving operation, is at fault.

CARCINOMA, OR CANCER OF THE SKIN

Cancer of the skin of the face is a very frequent form of new growth. Fortunately, in the vast majority of instances it is but locally malignant, which means that the new growth will not recur if it is properly eradicated and that it is not disseminated through the glands draining the particular area affected. However, a frequently recurrent injury over the uneven surface of the new growth may affect it adversely.

Because shaving furnishes just such trauma, it is not recommended.

DECALOGUE OF FALLACIES

Such a frequent procedure as shaving, practiced by great numbers under various hygienic and climatic conditions, naturally results in observations made under dissimilar conditions. This leads to the enunciation of generalities which may be true but which very frequently are true only in part and thus become fallacious when they are generally applied to the art of shaving. It has occurred to us that instead of writing a summary to this chapter on soap for shaving we utilize the space permitted us to point out some generalities which are fallacious, and we entitle this section the "Decalogue of Fallacies."

Fallacy No. 1. That it is the alkali in the soaps which causes irritation or sensitivity.

While this subject is still open to debate, there are evidences in the medical literature that this is not so. While free alkali in sufficient strength will dissolve hair and skin alike, the free alkali found in soap is not within this category. In our own experiment,[3] we have carried out shaving using milk of magnesia as a beard-softening agent, which is in itself a free alkali and has a much greater alkalinity than any soap. We tried it on the skins of especially sensitive people without finding any irritating effects.

Fallacy No. 2. That soap for shaving acts as a lubricant.

If the term lubricant is accepted in a limited sense—that it acts as an intermediary agent between two moving solid surfaces, then we accept the application of this term lubricant to soap for shaving. However, the term lubricant has a much wider connotation which is not applicable to shaving.

Fallacy No. 3. That duller razor blades cause more damage than sharp ones.

In the case of safety razors at least, exactly the opposite is true.[3] It is a most common observation that the sharper the blade the more easily it cuts into the skin and through the capillaries. Dull blades are responsible for increased pulling effects only, not for trauma.

Fallacy No. 4. That all shaving soaps are suitable for all individuals.

On account of different sets of circumstances existing in different individuals, in which the configuration of the bearded surface, the size and number of hairs, hair emergence angle, sensitivity, and also personal preference all play important roles, such an item as a universally satisfactory shaving soap is not attainable. One man's choice may be another man's displeasure and even searing flame. Thus, soap for shaving should not be chosen for its formula, or what manufacturers, advertising agents, blurbs, or even enthusiastic users say about it, but by what its action on the skin of the person in question happens to be.

Fallacy No. 5. That stiff lathers support the hair shaft and make close shaving easier.

The additional support to the hair shaft given by a stiff lather as compared with a loose lather is of minor effect and fails to prevent the hair shaft from turning over at a specific point in its penetration by the razor blade. Furthermore, a stiff lather forms a thicker film between the skin and the razor blade and therefore leaves a somewhat longer stump of hair protruding after the passage of the blade, which more than offsets its supporting effect. For this reason it is our experience that stiff creams, instead of promoting close shaves, do just the opposite. This fallacy may have arisen because of the palpatory illusion of lack of stubbles before the cream has been completely eliminated from the face.

Fallacy No. 6. That hard water makes shaving difficult.

This may not be wholly a fallacy. Hard water is water which reacts with the first soap that is put into it to take the soap out of solution. This first portion of the soap thus functions as a water softener, however expensive a water softener it may be regarded. Succeeding portions of soap then have the same effect in solution as they would have in soft water. Thus, hard water does not add difficulty to shaving, rather it makes it somewhat more expensive because it wastes soap. However, many are convinced that hard water also dulls blades.

Fallacy No. 7. That electric razors do not traumatize or irritate the skin.

This fallacy can be demonstrated by any user of an electric razor if he will put a strong alcoholic solution on his skin after he has shaved with an electric razor. The stinging and burning may be almost as great as with a safety razor. Shellow [15] described three cases of electric shaver dermatitis and stated that four others had come to his attention. He ascribed the dermatitis to either failure to cleanse the face or to friction caused by repeated going over the skin in an attempt to get close shaves.

Fallacy No. 8. That products are available which make rapid softening of the beard possible.

Rapidity of hair softening is governed largely by water temperature and only slightly by chemical properties of the product, except in the case of depilatories, which should never be used on facial skin.

Fallacy No. 9. That the best shaving soap is the one which is worked into a lather the fastest.

Just the opposite is true because the quickly worked up lather suggests to the shaver that softening of his beard is complete. We have shown that completeness of softening is affected mainly by time and water temperature, and therefore it cannot be assumed that a voluminous lather has accelerated it. From this viewpoint, slow-lathering toilet soaps may be even better than shaving soaps.

Fallacy No. 10. That self-shaving is an unpleasant task and that it is but a daily chore.

If all the requirements laid down for the obtaining of satisfactory shaving are observed, we believe that this so-called daily chore can be made the pleasant task of the morning. These requirements are made up of the following: (1) a good razor; (2) a suitable soap; (3) quantities of sufficiently warm water; (4) proper light for illuminating one's reflection from a good mirror; (5) ample time for both the preparational and shaving periods; (6) the acquired skill which results from daily practice; (7) the application of a suitable shaving lotion which reduces the occasional and minor discomforts resulting from unavoidable trauma in all shaving.

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8

Cutaneous Detergents Other than Soap

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Although soap has been known as a good detergent for many centuries, its almost universal use dates only from the early part of the nineteenth century. Previous to that time, water alone, oils, alkalies, and mechanical means were used for cleansing the skin. During the past two decades there has been developed a number of substances which are similar to soap in their detergent action. Most of these substances were originally developed for use in the textile industry, but during the past ten years they have begun to be used in cosmetics ("soapless" shampoos) and as cutaneous detergents. All of these substances may be grouped under the general classification of "surface-active agents." A major portion of this chapter will be devoted to this group because more satisfactory cleansing of the skin can be obtained with these materials than with water alone, oils, alkalies, or any of the detergents other than soap. These detergents will be considered in the following order:

1. Surface-active agents.
    - A. Definition, chemical characteristics, and classification.
    - B. Mechanism of cleansing.
    - C. Clinical applications.
    - D. "Sterilization" of the cutaneous surface.
    - E. Use as industrial cleansers.

2. Water.
3. Oils and oil solvents.
4. Alkalies, acids, oxidizing agents, reducing agents.
5. Cleansing by mechanical means.
6. Summary.

1. SURFACE-ACTIVE AGENTS

A. Definition, Chemical Characteristics and Classification

In a recent review of surface-active agents, Snell[1] defines such a substance as "one which modifies the properties of the surface layer of one phase in contact with another." A definition in such general terms is necessary because of the wide variety of substances correctly classed as surface-active agents and because of the various phenomena associated with surface activity. Wetting, deflocculation, emulsification, foaming, and detergency are primarily surface phenomena. The phases, too, may vary. They may be gaseous, liquid, or solid and the surface layers, therefore, may be at a gas-liquid, liquid-liquid, or liquid-solid interface.

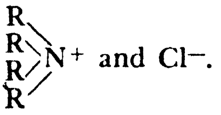
In any solution of a surface-active substance, there is a higher molecular concentration of the substance at the surface of the solution than within the solution, i.e., the molecules of the surface-active agent tend to concentrate at the surface. It is this surface concentration and subsequent orientation of the molecules that changes such measurable properties of the solution as surface tension and interfacial tension. Although all surface-active agents lower interfacial tension, they are not all equally good for wetting, emulsifying, and cleansing. In other words, a good wetting agent may not be a good detergent and, vice versa, a good detergent may not be a good wetting agent. A surface-active agent must be carefully chosen for the specific function to be performed.

The surface-active agents may be either liquid or solid. Many of those which are liquid have an oily appearance.

The solid materials may be amorphous, powdery, or crystalline. Most of the surface-active agents dissolve readily in water; their solubility in other liquids varies.

Although the surface-active agents vary widely in their chemical composition, they each possess both a hydrophilic (polar) group and a lipophilic (non-polar) group. The hydrophilic group is attracted to water and the lipophilic to oil. The hydrophilic groups in the more commonly used new detergents are the sulfates ($—OSO_3Na$ or $—OSO_3H$) and the sulfonates ($—SO_3Na$ or $—SO_3H$). The lipophilic group is usually a hydrocarbon or slightly modified hydrocarbon group. The properties of the surface-active agents depend to a large degree on the balance of hydrophilic and lipophilic groups in the molecule and on the position of the hydrophilic group or groups.

The surface-active agents are either anionic, cationic or non-ionic. In the anionic compounds, the active portion of the molecule carries a negative charge; in the cationic compounds, the active portion carries a positive charge. A non-ionic compound does not dissociate into charged particles. The sodium salt of sulfated lauryl alcohol is an example of the anionic compounds. It ionizes in aqueous solution as follows: Na^+ and $C_{12}H_{25}O \cdot O_2SO^-$. The quaternary ammonium compounds are cationic and hydrolyze as follows:



$$\left.\begin{matrix}\mathrm{R}\\\mathrm{R}\\\mathrm{R}\\\mathrm{R}\end{matrix}\right\rangle \mathrm{N}^+ \text{ and } \mathrm{Cl}^-.$$

Most of the new detergents retain their surface-active properties under more acid conditions than does soap. The addition of an electrolyte to the solution of a surface-active agent alters the surface properties of that solution.

While the exact chemical composition for many of the surface-active agents is not known, enough is known of their compositions to place them in various groups. There are many surface-active agents sold under various trade names. Several lists of these have been published (Mullin,[2] Schwartz,[3] Beeler[4] and van Antwerpen[5]). In the following classification,* the surface-active agents are divided into eight anionic, one non-ionic, and five cationic groups. Under these groups are placed the various skin detergents, shampoos, and household detergents according to the composition of their active ingredients as furnished us by their manufacturers. If a commercial product contains two or more surface-active agents, it is listed under each class into which its various constituents fall. The household detergents are mentioned because in the processes of laundering and dish-washing these substances do get into contact with the skin. With the recent increase in popularity of these materials, there are probably many that have been unintentionally omitted from the list.

Anionic Surface-Active Agents.

I. Sulfated oils. Oils, fats, fatty acids, and waxes of animal or vegetable origin, which have been "solubilized" by treatment with sulfuric acid. Examples: Sulfated olive oil; sulfated oleic acid.

Skin detergents: Acidolate; Allercreme; Almay's Sulfonated Castor Oil; Breck's Hand Cleanser; Dermalav; Detergol; Lavol; Liquid Hand Cleanser (Beauty Counselor); Liquid Tergent; Mixtures recommended by Klauder, Gross, and Brown.[7]

Shampoos: Admiracion; Mar-O-Oil.

II. Sulfated alcohols. Fatty alcohols esterified by treatment with concentrated sulfuric acid. Example: Sulfated lauryl alcohol.

Skin detergents: Breck's Hand Cleanser.

Shampoos: Drene; Lacene.

Household product: Dreft.

III. Sulfated or sulfonated fatty esters or amides. Examples: Sulfated lauric acid amide; sulfated ethyl laurate; sulfonated lauric acid amide.

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* This is a modification of the classification previously published by Lane and Blank.[6]

Skin detergents: Lowila; Praecutan; Satina; Tersus.

Shampoo: Halo.

Household product: Vel.

IV. Sulfonated alkylated aromatic hydrocarbons. Example: Sulfonated lauryl benzene.

Shampoo: Foaming Shampoo (Beauty Counselor).

Household products: Aliwol; Savex; Swerl.

V. Sulfonated ethers. Example: Sulfonated lauryl phenyl ether.

Skin detergents: van Antwerpen,[8] Guild.[9]

VI. Sulfonated aliphatic di-esters. Example: Sulfonated di-octyl succinate.

Skin detergents: Allercreme; see French.[10]

VII. Phosphated or borated fatty alcohols. Examples: Phosphated lauryl alcohol; borated lauryl alcohol.

Shampoo: Lacene.

VIII. Sulfonated hydrocarbons. Petroleum hydrocarbons or their derivatives are "solubilized" by treatment with concentrated sulfuric acid. Examples: Sulfonated paraffin; sulfonated naphthenic acid.

Non-Ionic Surface-Active Agents.

I. Hydroxylated fatty esters and ethers. Examples: Diethylene glycol stearate; polyether alcohol condensates.

Skin detergent: Dermalav.

Cationic Surface-Active Agents.*

I. Quaternary ammonium compounds.

II. Fatty amine salts.

III. Sulfonium compounds.

IV. Phosphonium compounds.

V. Oxonium compounds.

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* Many of these materials now exist only as laboratory preparations. So far as we are aware, there is no product on the market which is recommended primarily as a cutaneous detergent, shampoo, or household detergent, in which the active ingredient is a cationic surface-active agent.

B. MECHANISM OF CLEANSING

The mechanism whereby any detergent removes soil from the surface of the skin is complicated and not yet completely understood. Most of the investigation of this problem has been carried on with soap. Since soap is a surface-active agent, just as are the new detergents, it is likely that the basic principles of detergence by soap apply also to detergence by the other surface-active agents. Of the many papers which have been published on this subject, reference is made here to only three major reviews (McBain,[11] Fall,[12] Wetting and Detergency [13]).

The soil to be removed from the skin surface is composed of the materials excreted by the sebaceous and sudoriparous glands of the skin as well as everything which gets onto man's skin from his environment. Some soil is water-soluble and is easily removed by water alone, but most soil is composed of oily materials (insoluble in water) or small solid particles (dust and dirt). The oily soil, endogenous or exogenous, forms an oil-skin interface. The solid soil is probably held onto the skin surface more firmly because of this oily film and forms with this oil an oil-solid interface. In removal of the oily and solid soil from the skin surface, it is possible that at least part of these two types of soil may be removed as a single unit, i.e., the solid particles may retain their oily film. If this is the case, removal of even the solid soil must be considered primarily a process of emulsification. The oil-skin interface is replaced by two new interfaces, namely, skin-detergent solution and oil-detergent solution. If an oily film is also left on the skin, then the skin-oil interface is not broken and no new skin-detergent solution interface is formed. By establishing these new interfaces the oily soil is emulsified and the solid particles are suspended in the detergent solution. These new interfaces are formed more easily and thus the soil removed more easily by detergent solutions than by water alone because the free surface energy is less at soil-detergent solution interfaces than it is at soil-water interfaces. Efficient detergent solutions exert some dissolving action on the oil and keep the oily and solid soils in emulsion and suspension long enough to allow them to be rinsed from the skin with water.

No mention has been made so far of lather which has come to be accepted as a part of the cleansing process. Lather is a dispersion of air in a liquid. The liquid may carry some small solid particles. Lather aids in bringing about cleansing by mechanically removing some of the solid soil. It is possible, however, to cleanse the skin thoroughly without the formation of lather. Some of the new detergents do not lather and yet they clean the skin perfectly well.

In removing the soil from textiles, the electrical charges on the soil and on the textile fibers apparently play a role in the ease of removal of soil from the cloth. If both have the same charge, they repel each other and the soil can be more easily removed than when they have opposite charges and are attracted to each other. Most types of soil are thought to be negatively charged. Neville[14] and Sookne and Harris[15] have investigated these phenomena in the removal of soil from cotton and from silk and wool. So far as we are aware no similar study has been made for removal of soil from skin. Skin might be expected to have similar properties to wool, which has been shown to carry a positive charge at a pH below its isoelectric point and a negative charge at a pH above this point. (The isoelectric point of skin keratin has been estimated by various workers to be between 3.5 and 5.5.) Thus, the more acid the detergent, the more positive will be the charge on the wool (and possibly on the skin) and the attraction between the positively charged wool and the negatively charged soil will be increased, making cleansing more difficult. If this theory is correct for cleansing the skin, the very acid detergents would not be expected to cleanse as easily as alkaline detergents.

Further consideration must be given to the charge on the detergent ions. It has been stated that in solution the active portion of the anionic detergent is negatively charged and of the cationic detergent is positively charged. If the detergent ion has an opposite charge to the skin, the detergent may be precipitated onto the skin and inactivated. Thus, if the pH at which cleansing is being carried out is above the isoelectric point of skin keratin (skin may then be negatively charged), an anionic detergent, in which the active portion of the molecule is likewise negatively charged, is indicated; if below the isoelectric point, a cationic detergent is indicated. Thus, this hypothesis, which explains detergence only from the point of view of the electrical charges on the skin, soil, and detergent, would require that cleansing of the skin be carried out with an anionic detergent at a pH higher than the isoelectric point of keratin, under which conditions skin, soil, and detergent ions are each negatively charged and therefore do not precipitate or attract each other.

A major difference between soap and the new detergents is that the new detergents are more acid than is soap. The chemical composition of a soap is such that it is precipitated by acids or by the calcium and magnesium salts in hard water and much of its cleansing action is lost thereby. The new detergents are not precipitated by either acids or calcium and magnesium salts and thus retain their cleansing properties in either acid solutions or hard waters.

C. Clinical Applications

It has long been recognized that the skin of some individuals is irritated by the use of soap. With the advent of these new detergents, the question arises as to whether those individuals, who believe that soap irritates their skin, will find that the new detergents are not irritating. Vice versa, will some people who use soap without irritation to their skin be irritated by the new detergents?

Among the various investigators who have studied the irritating action of soap, some have felt that the alkali of the soap caused the irritation; others that certain of fatty acids were irritating. We believe that both the alkali and some of the fatty acids may irritate some skins.[16] The lower molecular weight fatty acids are more irritating than the higher molecular weight acids. All fatty acids seem to become more irritating in the presence of alkali, where they are present either as soaps or acid soaps. While the low molecular weight fatty acid may be irritating at a low pH, the higher molecular weight acids, if they are irritating at all, become so only at a relatively high pH.

The new detergents will, therefore, not irritate the skin in the same way that soap irritates since they are not alkaline. They may, of course, irritate the skin in some other way.

Soaps seem seldom to irritate the skin as a result of a specific acquired hypersensitivity (allergy) to the soap or some constituent in the soap. The new detergents have been used for only a short time and by a relatively few people. During this time, however, very few reports have been published of dermatoses resulting from their use. It would appear that in general these detergents have a low index of sensitization.

Some of the earlier reports of skin irritation from contact with sulfated oils (Group I) among rayon workers (Osborne and Putnam)[17] and from a contact with a finishing oil used on socks (Schwartz)[18] can probably be explained on the basis of the presence of substances other than the sulfated oils or impurities in the sulfated oils due to a poorly controlled sulfation process. In this country, this group of detergents has probably been used more as cutaneous detergents than any other type of surface-active agent.

Blank[16] recommended the use of a mixture of sulfated oils, liquid petrolatum, and water as a detergent for contact and atopic dermatoses, reporting a very low percentage of irritation due to this detergent among 150 cases. A further clinical investigation of this same detergent was made in ten different dermatologic clinics, the results of which were compiled and reported by Lane and Blank.[19] This sulfated oil was used by patients with various diseases of the skin. The results of this investigation indicated that over 92 per cent of these patients could use this material as a detergent without aggravating their cutaneous conditions. Lane and Blank[20] have more recently reported the use of this sulfated oil detergent without irritation as the only detergent used over the period of one year in a nineteen bed dermatologic ward.

Reference to the above table of classification shows that several other cutaneous detergents and shampoos, which are similar chemically to the mixture recommended by Blank,[16] are now available. Klauder, Gross, and Brown[7] have found several different sulfated oils to be satisfactory skin cleansers. French[10] stated that patients do not like the oily feel and lack of lather of this group of compounds and recommended a detergent belonging to Group VI. Quimby and Fiero[21] found a mixture containing sulfated hydrogenated castor oil as the active ingredient to be a satisfactory, non-irritating detergent. Sharlit[22] states that the detergents in this group are less irritating than some of those in the other groups, but in general he prefers a properly prepared superfatted soap to any of the new detergents.

Bauer[23] first recommended the sulfated esters (Group III) as non-irritating cutaneous detergents for use by individuals who have skin diseases such as eczema, exfoliative dermatitis, and psoriasis, and who find soap an irritant to their skin. Schmidt and Straub[24] found that they remove soil more completely than does soap. Jordan, Dolce, and Osborne[25] found that 26 out of 27 patients who were allergic to soap could use a detergent containing lauryl sulfoacetate (Group III) without irritation.

The sulfated alcohols (Group II) have been used extensively as shampoos and dentifrices, but infrequently as cutaneous detergents. Soon after these materials began being used as shampoos, Carpenter[26] and Biederman[27] reported occasional irritations due to their use. But the use of these shampoos is now quite common and widespread and there has not been a corresponding increase in reports of irritation from them.

No reports of clinical investigation of the use of these compounds as cleansers by those whose skin is irritated by soap has been found. There have been reports of their pharmacology (Smyth, Seaton, and Fischer[28]), their toxicity when used as dentifrices (Halton, Fosdick, and Calandra;[29] Epstein, Throndson, Dock, and Tainter[30]), and the results of patch tests to sodium alkyl sulfate (Emery and Edwards,[31] and Goldman[32]). The report of a relatively high percentage of positive patch tests to some of these substances, a finding which we have confirmed, does not necessarily indicate that these same materials will be irritating when used as shampoos or cutaneous detergents. When a substance is held on the skin as a patch test, it is in contact with the skin for a much longer time under far different conditions and probably at a different concentration than would be the case if it were being used to cleanse the skin. An erythematous reaction to a patch test does not necessarily indicate that the same substance will produce an erythema when used as a detergent. Also it is possible with some of these new detergents that when a patch test is applied, it may be the first time that such a material has touched the skin of that individual. In this case, the result of the patch test gives no information about the possibility of that substance being a sensitizer. A negative patch under such conditions does not indicate that the material in question is safe to use. Repeated application of the material to the skin might result in sensitization and subsequently the patch test to the same material would give a vesicular reaction. Thus, the results of patch tests must be carefully interpreted and final judgment of the mildness or irritating action of a detergent must await the results of adequate clinical trial.

Materials in Group IV have been used as household and industrial detergents. No published reports have come to our attention showing the action of these substances on the skin when they get into contact with the skin in connection with their use as household detergents. Likewise, we have seen no detailed published reports of the action of the sulfonated ethers (Group V) on the skin. Guild[9] feels that cutaneous detergents and shampoos made from a representative of this group are seldom, if ever, irritating. Schwartz[33] says that some of the substances in Group VI and other surface-active agents may be incorporated into industrial cleansers.

D. "STERILIZATION" OF THE CUTANEOUS SURFACE

Some years ago "sterilization" of the skin surface as a result of washing with soap and water was thought to be due to the germicidal action of soap. Price[34] has emphasized the fact that soap is not a very good germicide for many types of bacteria and that whatever "sterilization" occurs results more from the detergent action of soap than from its actual killing action. Bacteria may be considered a type of solid soil and they may be removed from the skin by soap solution in just the same way that solid dirt particles are removed. In this respect, it seems probable that solutions of detergents other than soap will likewise remove bacteria from the skin surface; some may be more efficient than soap, others less efficient. No actual report of this property of detergent solutions has been found in the literature.

In addition to the ability of the surface-active agents to remove bacteria from the cutaneous surface, some of them seem to be relatively good germicides. Birkeland and Steinhaus,[35] Scales and Kemp,[36] and Baker, Harrison, and Miller[37] have published reports of work of this nature. The latter investigators determined the ability of various surface-active agents both to kill and to alter the metabolism of several species of bacteria. All of their work was carried on at a pH of 7.0. They found that the cationic detergents, as a group, exhibited "marked bactericidal effects on Gram-positive micro-organisms and somewhat less pronounced action on Gram-negative organisms. The anionic detergents were germicidal only against the Gram-positive organisms and they were considerably less effective than the cationic compounds."

Gershenfeld and Milanick,[38] working with a smaller group of surface-active compounds, found that the bactericidal activity of these compounds was markedly influenced by the pH of the solution. The one cationic detergent with which they worked was a good bactericide against both Gram-positive and Gram-negative organisms at a pH above 7.0 but was relatively poor at lower pH's. The anionic detergents were more efficient in the acid pH range.

In skin "sterilization," the Gram-positive organisms are usually more important than the Gram-negative organisms. When the synthetic detergents are used, detergence is usually carried out at a pH from 6 to 9 which is lower than that of soap. Independent of the relative bactericidal properties of the various detergents, the anionic detergents may be found to be more efficient skin "sterilizers" than the cationic detergents because removal of the bacteria may be more important than actual killing of them, and the electrical charges on the skin, bacteria, and detergent may be such that the bacteria are removed more efficiently by the anionic than by the cationic detergents. More specific work of this nature carried out directly on the surface of the skin, together with measurements of the rate of removal of bacteria by various detergent solutions, should prove valuable in determining optimum methods for skin "sterilization."

E. USE AS INDUSTRIAL CLEANSERS

It has long been recognized that improper cleansing methods are contributing factors in the production and continuation of occupational dermatoses. Even when the cleansing method is not originally responsible for an occupational dermatitis, the dermatitis may be worse or may be continuing long after the original causative agent has been removed, because of the type of cleansing agent used by the worker. Klauder, Gross, and Brown[7] and Schwartz[33] have emphasized this point of view in this country and have recommended several non-irritating cleansers. In general, these cleansers are sulfated oils with small amounts of some one of the other synthetic detergents added. In Europe, Ruf[39] and Schreus[40] have recommended detergents belonging to Group III as industrial cleansers. Each of these investigators feels that occupational dermatitis is appreciably lessened if proper cleansing methods are used.

Specific instances of the beneficial use of cleansers other than soap have been reported for cement dermatitis (Pincus[41]) and cable rash (Morris and Tabershaw[42]). It is possible that thorough cleansing with these detergents might reduce the incidence of oil dermatitis and folliculitis among those who get their skins very oily in connection with their occupation. With rapidly increasing use of these cleansers in industry, it is to be expected that there will soon be many reports of the use of these cleansers in specific types of occupational dermatoses.

2. WATER

Water is seldom used alone as a cutaneous detergent, but it is used in conjunction with all other cleansers except the oils and oil solvents. By itself, it will remove only the water-soluble soil and whatever insoluble soil can be "flushed" off by it. Running water, such as a shower bath, gives more efficient cleansing than simple immersion. Water used for washing the skin will contain varying amounts of dissolved inorganic salts. These salts combine with some of the detergents, principally soap, to form insoluble substances which precipitate onto the skin.

When water is in contact with the skin, some hydration of the cells of the stratum corneum undoubtedly occurs. This hydration is probably at a minimum when the water has a pH equivalent to the isoelectric point of the skin keratin. When the pH of the water is either higher or lower than the isoelectric point, hydration of the cells increases.

Only rarely are any complaints heard about the harmful effects of water on the skin. An occasional patient will state that water is "bad" for his skin. Many complain that hard water "dries" the skin. Rarely a "bath itch" is observed in an individual following each immersion in water even when no soap is used. No conclusive evidence has been found in the literature, however, that water by itself, either hard or soft, has any harmful effect on the skin. Long, continuous contact or frequent, intermittent contacts with water may cause hydration of the skin which may predispose the skin to bacterial invasion or irritation by some other substance.

3. OILS AND OIL SOLVENTS

The use of oils for cleansing the skin antedates the use of soap. Since more of the soil is oil-soluble than is water-soluble it is understandable why oils were used as cleansing agents. Oils and oily emulsions have been popularized by the cosmetic manufacturers as cleansing agents which do not "dry" the skin as much as do aqueous cleansing methods. When oils have been used for cleansing the skin, it is difficult to remove all of the oil. This oil which remains on the skin will serve as a mild emollient. If one does not object to the residual oily feel of the skin, such a cleansing method is probably satisfactory for the individual whose skin is deficient in natural oils. This condition occurs principally in people in the older age group.

Occasionally one finds scattered pustules on the skin of persons using oil frequently for cleansing. The oil folliculitis occurring in machinists and other workers in oily occupations is well known.

Oil solvents are relatively frequently used as cleansers by workmen, particularly those who get grease and paint on their skins. Klauder, Gross, and Brown[7] have stated that they feel that many of these materials may irritate the skin.

Smith[43] lists at least sixteen such solvents and feels that they may be injurious because they not only remove oily soil but also remove most of the natural occurring skin fats, thus reducing the skin's resistance to heat and cold and favoring possible absorption into the blood stream. Irritations from the use of gasoline, turpentine, etc., which are more severe than simple dryness, are not infrequent.

4. ALKALIES, ACIDS, OXIDIZING AGENTS, AND REDUCING AGENTS

Alkalies are infrequently used as detergents. Alkaline salts, frequently however, are added to other detergents to improve the cleansing properties of those detergents. Such materials, when added to soaps, are called "builders." Any alkaline salt capable of doing much cleaning by itself will probably irritate the skin. It may react chemically with the keratin of the stratum corneum.

Jones, Murray, and Ivy[44] have recommended sodium hexametaphosphate, which has a slightly acid reaction, as a mild detergent. It is a poor cleanser when used by itself.

Oxidizing and reducing agents are used as cleansers only in specialized cases. Workers with dyes often find that they can cleanse their skin only by chemically destroying the dyes. This is accomplished by use of an oxidizing or reducing agent. Bleaching water, an oxidizing agent, is often used. Bleaching water is usually an aqueous solution of calcium or sodium hypochlorite and in addition to being an oxidizing agent, it is a strong alkali. It is very irritating to most skins and should be avoided. Potassium permanganate is another oxidizing agent. The sulfites and thiosulfates are the more commonly used reducing agents.

5. CLEANSING BY MECHANICAL MEANS

Removal of soil by mechanical means alone is usually unsatisfactory since most soil is quite adherent to the skin.

Mechanical processes, however, are part of almost any cleansing technic. The brush and the wash cloth are used as definite aids in the removal of soil by various detergent solutions. Abrasives are often added to industrial soaps and to some types of household cleansers. An inert powder may remove soil by sorption onto its surface. Of course, the only action which these cleansers can have on the skin is a physical action.

Rigorous mechanical cleansing can injure the stratum corneum. Injury to the stratum corneum may be a forerunner of irritation by some other substance. The abrasive action in the so-called "sand soaps" is thought to be a major factor in the irritation sometimes caused by these industrial cleansers.

6. SUMMARY

Before soap became universally used, water alone, oils, chemicals and certain mechanical measures were used for cleansing the skin. Except in special instances these materials have not been satisfactory and have been supplanted by soap and water.

In recent years, other materials have been developed which have cleansing properties equal to or better than soap. Although many compounds of widely varying composition belong to this group, they may all be classified, along with soap, as surface-active agents. Each possesses both a hydrophilic and a lipophilic group. They differ from soap primarily in that they retain their detergent properties in acid solutions and are not precipitated by the calcium and magnesium salts which are present in hard water. It is probable that they remove soil from the skin in the same way as does soap.

Both the alkali in the soap and the type of fatty acids present are factors in any irritation produced by soap. The new detergents may be prepared free of alkali and irritating fatty acids. Some of these detergents give good indications of being less irritating to some skins than is soap. They also seem to be satisfactory non-irritating industrial cleansers. Clinical use, up to the present time, indicates that a very small number of patients are irritated by these detergents. Most of these detergents, however, have not yet been used long enough to determine whether they may sensitize many skins.

Some of the new detergents seem to be better germicides than is soap. It is probable that they will remove microorganisms from the cutaneous surface at least as efficiently as does soap.

Clinical experience up to now indicates that these detergents will be more widely used when a low-cost cake form is developed which will lather and which has satisfactory physical properties.

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9

The Medical Uses of Soap

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Cleanliness is important for the functioning of the skin. Soap is the generally accepted cleanser for the skin because years of experience have shown that soap will remove both visible and invisible dirt. Invisible dirt includes bacteria and small amounts of material in the form of secretions of glands in the skin and the fine dusts that occur in industry.

Much has been said about the ability of soap to destroy germs on the skin and about the value of a lather to remove infection. The average person who washes his hands with soap exposes the skin of the hands to the action of the lather for less than a minute. The chief value of the soap in such cleanliness is therefore in its ability to dissolve and remove material rather than to destroy living organisms.

In "The Technic of Medication," Dr. Bernard Fantus[1] called soap the single most important cosmetic. He said, "The superstition that soap and water are bad for the complexion probably arose at the time, long since past, when soaps contained an excess of alkali and, therefore, did tend to irritate the skin. Nowadays it is only in exceptional cases that the skin of the face is irritated by toilet soaps."

In his discussion of the use of various remedies for inflammations or infections of the skin, Dr. Fantus suggested that cleansing of the lesion should be the first step in dermatologic practice. The application of remedies to areas covered with crusts or scales is futile because the crusts or scales interfere with the contact of the remedy with the lesion. In some instances acute dermatoses are injured by washing with soap and water, and do better with applications of creams and ointments.

An extremely delicate skin may be quite sensitive to soap, particularly if the soap contains alkaline builders. As Dr. Sulzberger has pointed out repeatedly, when eczema occurs on a baby's skin, alkali from any source is likely to produce serious irritation. Therefore a pure, mild, neutral soap should be used to cleanse both the baby and any clothing that may come in contact with him. Dr. Sulzberger recommends that the greatest care be taken to see that soap does not remain in the clothing or bed linen of the infant. Under severe circumstances, when even the slightly alkaline reaction of pure mild soap cannot be tolerated, the skin is cleansed with warm water containing a small amount of bran, starch, or oatmeal. The scalp is much less sensitive to the effect of irritants than is the skin in general.

SOAP IN FIRST-AID

Dr. Robert Lee Kerrigan [2] reported that soap and water, according to the technic developed by Drs. Sumner L. Koch and M. Mason, had been adopted in an industry for cleansing wounds. He used tincture of soap and, in more recent years, a neutral white soap solution. In his technic, the wound was first covered by sterilized gauze; loose clots, foreign bodies, and devitalized tissue were removed. The wound was gently repacked while the coverings were being removed, and everything made ready for the final cleansing. Soap and water washing of wounds was consistently carried out in 12,044 open wounds over a period of five years to the exclusion of chemotherapeutic agents. Hospitalization was necessary in only eighteen cases in which the primary care consisted of white soap and water cleansing, accompanied only by the excision of devitalized tissue.

Dr. Sumner L. Koch [3] has reported the preparation of the donor site for skin grafting and also the area around the wound where the skin grafting is to be done by thorough cleansing with plain white soap and water and without antiseptics. Infection did not occur.

Drs. R. H. Jackson and R. H. Jackson, Jr.,[4] found that mechanical cleansing with soap and water just before closure of a wound efficiently and harmlessly removed agents of primary wound infection with staphylococci, streptococci, and similar germs likely to be present in the air.

Dr. C. Glenn Barber[5] also prepared donor areas for skin grafting by scrubbing freely with soft soap U. S. Pharmacopoeia and water before rinsing with sterile water and washing with 70 per cent alcohol.

Dr. J. E. Walker[6] found that thorough washing of the hands with the formation of a good lather will destroy any adhering diphtheria bacilli, streptococci, and pneumococci. He states that any ordinary good soap will serve for this purpose. Many micro-organisms are not affected by soaps. The disinfectant action of the soap is a combination of physical and chemical effect. A solution of soap will not disinfect sputum or feces. Many of the studies that have been made of the value of soap for bacterial cleansing of the skin have failed to take into account the fact that there are germs that are on the surface and those which are practically resident on the skin.

Dr. Philip B. Price[7] found that scrubbing with soap and water will remove transient germs readily, but resident germs far more slowly. In his experiments, scrubbing for removal of germs required trimming the nails short and scraping them carefully to remove all visible dirt, then scrubbing conscientiously for seven minutes, using warm water, abundant soap and a brush of medium stiffness with well-packed bristles of equal length. Every part of the hands and arms should receive their share of the brushing before preoperative routine. Greasy or grossly soiled hands will require at least ten minutes of scrubbing. The largest variable affecting the rate of reduction of germs was the amount of vigor used in the brushing, the sort of soap used, and the sterility and temperature of the water.

In a recent report on anti-infective and germicidal soaps, the Council on Pharmacy and Chemistry of the American Medical Association reviewed available information regarding many soaps now on the market which are claimed to be germicidal. Some of the studies that have been made indicate that streptococcus pyogenes is susceptible to the action

SOAP IN SCABIES

Scabies has been treated by the use of a soap containing twelve grains of sulphur or by some other lathering agent containing twelve grains of sulphur. In the Carter technic the person with scabies takes a hot scrubbing bath, the tablet is rubbed into a lather and the lather is applied all over the body, then the underwear is put on after the lather has been allowed to dry. This serves the double purpose of cleaning and the continuous application of sulphur.

SHORTAGE OF SOAP IN WAR

The following statement from the International Labour Office[8] indicates how the war affected the supply of soap in the occupied nations:

> Among the articles of prime necessity which are becoming scarcer and scarcer in occupied Europe, one of the most important is soap, which is doled out in small quantities and is of very poor quality. According to the American Friends Service Committee, in France, at the end of 1941, the soap supply consisted mainly of small clay-like cakes containing not more than 12 per cent of fat. Officially, the fat content of household soap, which was 72 per cent in 1939, was reduced to 40 per cent in January, 1942, 30 per cent in the course of the rest of 1942 and 20 per cent in January, 1943. The theoretical monthly soap ration in France in February, 1943, was 100 grams of toilet soap or 37.5 grams of household soap per person; children under 3 years of age were entitled to 187.5 grams of household soap and those between 3 and 6 years of age to 75 grams, while all other consumers received a supplementary allowance of 37.5 grams of household soap or 120 grams of washing powder, consisting of ammonia or some other detergent mixed with a little soap powder. . . . In Greece, too, soap is practically non-existent, a condition which encourages the spread of disease and epidemics.

SOAP IN HYGIENE

The American people consume ordinarily about twenty-five pounds of soap per person per year. A shortage in the supply of soap is important in relation to health of the community. This is particularly the case during war because of the employment of an increased number of workers in heavy and dirty industries which required more use of soap, large movements of population from rural areas where less soap is needed to urban areas where more soap is needed, and the substantial increase in the number of births, since the proper bathing of the infant is vital in relation to health.

In the prevention of respiratory diseases, such as the common cold, influenza, and pneumonia, and in the prevention of the dysenteries which are especially a war hazard, the factor of cleanliness cannot be too greatly emphasized. Carefully controlled research in the army and in large industries has demonstrated that frequent and thorough washing of the hands, particularly of food handlers and others associated with large-scale food projects such as are inevitably a part of the war effort, is most important in lowering the incidence of disability from various diseases. The phrase "hand to mouth infection" is now well established as a recognition of the danger of unclean hands in spreading disease. The worker in war industries suffers from many forms of disturbance related to failure to remove toxic substances by thorough washing of the entire body with soap and water.

The Council on Industrial Health of the American Medical Association and the regulations of practically all state industrial commissions demand a definite provision for thorough washing with soap and water in all industries. Reports received from many foreign countries indicate that disease rates increase in relation to restrictions on the supply of soap and water for cleanliness. All of the diseases recognized as filth diseases are related to cleanliness. Obviously cleanliness of the body cannot be maintained without suitable cleaning and disinfection of clothing. The skin thoroughly washed may be contaminated by putting soiled clothing back on the body, or by sleeping between sheets that have been contaminated by human excretions. The factors here mentioned have been recognized by most authorities.

Florence L. Meredith[9] in her textbook on hygiene writes:

> No other single article can compare with soap in respect to the amount of sickness and death prevented by

> its use. Epidemics rage where little soap and water are used for personal and domestic purposes. Uncleanliness of habits of living may be considered responsible for more ill health than any other one cause.

Dr. Thurman B. Rice,[10] health officer of the State of Indiana, says:

> A characteristic of the modern age is that it uses soap and water far more freely than has any previous age. A certain amount of soilage is inevitable as one goes about his work or pleasure. Such soilage is likely to convey infectious material to the skin and hands. Little harm need come of it, however, if the hands and the skin are washed as often as may be needed to send the germs into the drain before they have been able to make their attack. In our opinion the biggest accomplishment of modern times is to be seen in the fact that a civilized community takes means to make itself and its individual members clean.

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10

The Surgical Uses of Soap

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Cleanliness is an integral part of modern surgery. Until the concept of eliminating bacteria from the operating field was recognized and designated as "aseptic surgery," the results obtained by present-day surgical technics were impossible. Soap, as the most important and widely used cleansing agent other than water, from the beginning has played a primary role in attempts to achieve cleanliness in the surgical sense. The importance of the use of soap in conjunction with operative procedures cannot be exaggerated.

PREPARATION OF THE HANDS AND SCRUBBING BEFORE OPERATION

The sterilization of the hands and forearms before undertaking an operative procedure is a recognized part of modern surgical technic. The first step in such sterilization consists in mechanical cleansing with soap and water; indeed it is probable that this mechanical cleansing does as much or more to eliminate bacteria from the skin of the surgeon as do the disinfecting agents commonly applied afterwards. The technic of cleansing or "scrubbing" varies in different institutions, the time during which scrubbing is carried out being an important element in the degree to which bacteria are eliminated from the skin. Christopher[1] suggests the following technic: "The fingers, hands and forearms up to and including the elbows, are then scrubbed" (after paring the nails and dipping the tips of the fingers in 3.5 per cent tincture of iodine) "under hot running water with green soap and a good stiff brush for at least five minutes. The hands are then raised, and the water is allowed to drip off the elbows. The hands and forearms are then placed in 70 per cent alcohol, which is also allowed to drain off at the elbows."

Maes and Ilgenfritz in their chapter on "Aseptic Surgical Technic" in Lewis' "The Practice of Surgery,"[2] describes the process of scrubbing as follows: "The hands and forearms, including the elbows, are scrubbed with a firm but not stiff bristle brush for several minutes according to a routine procedure. The dorsum of each hand is scrubbed first, then the palms and the fingers individually, special attention being paid to the nails. The forearms and elbows are scrubbed last. After three minutes of scrubbing the brush is discarded and the fingernails are cleaned with a sterile orange stick. Scrubbing is then resumed with a fresh sterile brush for another five to seven minutes by the clock. Either tincture of green soap or a cake of soap held continuously in the hands may be used. The hands are kept constantly above the level of the elbows, especially when the soapy lather is rinsed off."

Some surgeons prefer tincture of green soap, others castile soap, and some advocate plain white soap. There does not seem to be any clear-cut evidence that any one of the soaps in common use for this purpose eliminates more germs from the skin than do others.

It has been pointed out[3] that spores of bacteria may survive in tincture of green soap in spite of its alcoholic content. Although the question has been raised of the desirability of sterilizing tincture of green soap by autoclaving, it seems improbable that this procedure is undertaken with any great degree of frequency or is usually necessary.

The evidence indicates that the value of soap in scrubbing before operation lies in its mechanical cleansing action and the time spent in the process rather than in any germicidal action. Walker[4] has shown that although pneumococci and streptococci are highly susceptible to the germicidal action of soap, staphylococci are quite resistant.

PREOPERATIVE USE OF SOAP ON THE SKIN

The use of soap on the skin of a patient being prepared for operation is such an established practice that it has received little discussion in medical writings in recent years. Christopher[1] states the objective is "to render the field of operation as nearly sterile as possible." He points out that actually the problem is not so simple, for sterilization should be thorough and last for hours and yet must be accomplished with a minimum of irritation and injury to the skin and tissues and above all must not interfere with the healing of the wound. Although the technic varies with the individual he lists two preliminary steps as essential. "(1) All hair should be removed with an adequate margin by shaving. (2) All gross dirt should be removed with soap and warm water." This should be done some time before the scheduled operation.

Maes and Ilgenfritz[2] feel that it is best to cleanse the area the night before the operation and then use a fat solvent and non-irritating antiseptic just prior to the operation in order to remove or kill the organism inhabiting the sweat glands and hair follicle. They point out, however, that some surgeons rely solely on soap and water scrubbing because of the dangers from burns when certain antiseptics are used.

SOAP AND WATER TREATMENT OF THE OPERATIVE WOUND

A number of surgeons, recognizing the successful use of soap and water cleansing in the treatment of traumatic wounds (see later), have considered the use of the same treatment for surgical wounds. Jackson and Jackson[5] in their studies, used a sterile soap solution containing 5 per cent or somewhat less of operative green soap for the cleansing of operative wounds. They dipped a gauze sponge into the soap solution and applied it to the wound, maintaining a minimum cleansing time of two minutes for small wounds and five or more minutes for large wounds. After cleansing they packed the wound with dry gauze and closed the wound lips with towel clips. They then cleansed the surrounding skin area and sponged it with alcohol. They were then ready to suture the wound.

They reported the successful treatment of over 200 operative wounds by this method without a single instance of interference with primary wound healing. As a result of their studies they reached some very definite conclusions which can be summarized as follows:

Wound infection from staphylococci and streptococci normally averages 5 per cent of the operative cases, but at times goes to as high as 20 per cent. Surgical wounds develop a film which catches and holds bacteria from the air in the operating room. By means of mechanical cleansing with soap and water just before closure of the wound, the chance of primary infection from staphylococci and streptococci is efficiently and harmlessly removed. The treatment aids ideal wound repair, as shown by the fact that a very high percentage of cases heal with complete placidity, no redness, induration of irritation. In conclusion, Jackson and Jackson state: "We are convinced (after further trial) that this method is a harmless, inexpensive efficient procedure. . . ."

USE OF SOAP AND WATER IN THE TREATMENT OF TRAUMATIC WOUNDS

Christopher[6] says that the importance of proper cleansing with soap and water cannot be overemphasized and quotes Koch's authoritative statement: "Briefly, our plan of procedure is to cover the wound itself with sterile gauze; then with cleansed hands, or hands covered with sterile gloves and with sterile sponges, to wash a wide area about the wound gently but thoroughly with soap and water; finally to remove the sterile gauze covering and protecting the wound, and to wash the wound itself patiently, gently, but thoroughly with soap and water. If the wound is irregular and deeper pockets are present underneath torn flaps of skin and subcutaneous tissue this process of cleansing the deeper portions of the wound with soap and water is repeated after the sterile linen has been placed about the field of operation, and while the wound edges are held back with sterile retractors. Finally, any excess of soap solution is washed away with more sterile water. No antiseptic solutions such as tincture of iodine or hydrogen peroxide are used, either around the wound or in the open wound.

"Such cleansing with soap and water may be all that is necessary to convert the contaminated wound into a clean wound. If, however, injured or devitalized tissue is present it should be excised, with every care both to make such excision complete and not unnecessarily to sacrifice sound tissue.

"The next step is repair of the deeper tissues and closure of the wound; and so conversion of the compound injury into a simple injury. If one is satisfied that cleansing of the wound has been accomplished, it seems to us quite as illogical to leave the wound open for an indefinite period as it does to leave a herniotomy wound open after repair of the defect in the muscles and fascia. Complete healing and restoration of function will take place most rapidly if the open wound is closed and heals without infection. The wound left open is certain to become infected within a few days.

"If at the primary operation one is in doubt as to whether cleansing of the wound has been accomplished it is always possible to pack the wound lightly with a non-irritating dressing, such as gauze saturated with petrolatum, and carry out a delayed closure twenty-four hours later. If cleansing has been accomplished the wound can still be closed, and still heal by primary union."

The basic rules, or cardinal points, that must be followed for best results in the treatment of traumatic wounds have been set forth by many investigators. None have stated the problem more clearly than Koch,[7] whose views can be summarized as follows:

Neither contamination nor trauma should be added to the wound. As soon as possible, transform the contaminated wound to a clean wound. If this can be done a few hours after injury, repair the injured structures and close the wound. If many hours elapse after injury, cleanse the wound but do not repair injured structures. Use a dressing that rests the injured part and provides an even and constant pressure over the wound.

Koch points out that frequently surgeons striving primarily to make the contaminated wound a clean wound, use chemical solutions that are effective in this respect but at the same time destroy the living tissues which are the strongest protection against bacterial infection. He concludes that the method which is most effective and carries the least risk of injuring the exposed and vulnerable tissue is cleansing with plain white soap and sterile water for 10 minutes or more, followed by irrigation with warm saline solution.

Webb[8] views the problem of lacerated wounds in much the same light as Koch. He recommends the soap and water method as the best method to convert a contaminated wound to a clean wound and points out that it is definitely superior to the use of iodine or some other antiseptic. He stresses the importance of having an established routine familiar to both the surgeon and the nurses, and gives details of the routine he uses. Once the details of the procedure are established, the procedure becomes simple, easy to apply and the after-results are good.

Kerrigan[9] reports the results obtained in an extensive study of cases of traumatic wounds treated with soap and water. The number of patients treated: 12,044 in a 5-year period leaves no question as to the reproducibility of the results obtained. His general procedure was similar to that of Koch and Mason; it involved cleansing the tissues with a neutral white soap solution applied with sterile cotton gauze.

Kerrigan suggests the establishment of gentle soap and water cleansing as the basic procedure for traumatic wounds. He concludes:

"The study of 21,862 injuries resulting in 12,044 compound wounds, revealed that hospitalization was necessary in 18 cases in which the primary care consisted of white soap and water cleansing and excision of only devitalized tissue. Seventy-five per cent of these compound injuries involved the wrist and hand. Of these 9,195 cases only 10 patients required hospitalization. Because these injuries were so uniformly contaminated and so difficult of cleansing, and further, because in no instance in which primary soap and water cleansing was given, was it necessary to hospitalize an individual for infection, we feel that this is the severest test for the efficacy of the method."

SOAP AND WATER TREATMENT OF BURNS

Soap and water cleansing has been suggested for the treatment of burns. Some investigators have used the true soaps for this purpose while others have worked with the new synthetic detergents.

Siler[10] considers the injury sustained by a burn as comparable to a traumatic open wound and recommends it be converted from a potential infected wound to a surgically clean wound by the same procedure. Specifically, he recommends washing with white soap and water for 10 minutes followed by irrigation with physiologic saline while under general anesthesia. After debridement, followed by a second white soap and water washing and saline irrigation, a surgical dressing is applied and left in place one to two weeks. This procedure has proved itself in a series of over 100 cases. There is considerable evidence that "thermal shock" and complex blood concentration syndrome are prevented. The method is simple and requires no further local treatment. It has the big advantage over other treatments, particularly tannic acid, silver-nitrate, in that the patient is able to move or be moved easily, thus minimizing danger from upper respiratory tract infections.

One hundred and sixty-five surface active agents manufactured in the United States were studied by Schwartz and Mason[11] to determine their value in cleansing burned skin of oil. The test oils employed were heavy and light fuel oils. Three mixtures of surface-active agents were found capable of completely removing heavy fuel oil without apparent mechanical action in the course of three fifteen-minute applications on surgical gauze, but they had poor detergency. Dioctyl sodium sulfosuccinate in 10 per cent light liquid petrolatum solution had good detergency and high activity as an oil remover in dressing form. This study is illustrative of work on the action of soaplike substances in special surgical fields.

Rosenberg[12] found that certain of the synthetic detergents had unique properties which made them superior to other cleansing agents when the burn was contaminated with greases, oils, and fats.

THE EYES

According to Scholz,[13] the preoperative cleanup of eyes presents a problem different from that encountered in other parts of the body. This is due to the looseness of the skin of the lids which makes penetration of the crevices difficult and to the sensitivity of the cornea and conjunctiva which precludes the use of substances which are irritating. He studied a detergent compound of a mixture of sulfonated alcohols for this special purpose. It was found to have superior properties and lowered irritability. The compound was used in the routine preoperative cleanup of lids, brows and adjacent skin at the Wilmer Ophthalmological Institute of Johns Hopkins Hospital. Scholz believes that the experimental and clinical results with this substance indicate that it is superior to the soaps ordinarily used for the purpose.

CHOICE OF SOAP

There seems to be no clearly established soap for surgical procedures, although white soap or tincture of green soap is normally used. The mildness of the soap is the criterion by which the soap is usually selected.

Some effort has also been made to select soaps on the basis of germicidal value. In view of the established fact that the soap and water technic owes its success largely to the removal of bacteria without harm to the tissue, the use of germicides in soap has been of secondary interest. Nevertheless many studies have been made in this field.

Tilley and Schaffer[14] tested the bactericidal efficiency of coconut oil and linseed oil soap against *B. typhosus, B. pyocyaneus* and *Staphylococcus aureus,* and found the former more efficient under the technic of the test.

Walker[4] in a series of studies on the same subject found that the most readily available commercial soap which was effective against typhoid bacilli, paratyphoid and dysentery bacilli was salt water soap prepared exclusively from coconut oil.

Davison[15] studied the detoxifying, diffusing, germicidal and surface tension depressing properties of twelve common soaps. He found that those soaps which possessed high detoxifying ability, ready diffusibility and high germicidal effect were correspondingly poorer surface tension depressants.

The work of Price[16] on this subject is classic. Scrubbing with soap and water, he found, reduces the basic flora at a constant logarithmic rate roughly by one-half each six minutes or by two-thirds each ten minutes of scrubbing. Theoretically, it would require two and a half hours of continuous scrubbing to sterilize the skin.

Using a modification of Price's technic, Pohle and Stuart[17] carried out handwashing experiments with soaps to which rosin had been added for germicidal effect. The worth of this substance was difficult to evaluate but the method employed was considered suitable for determining the germicidal action of rosin soaps.

A series of studies in the German literature,[18] with special emphasis on the importance of the pH, like the other reports in the American literature, fails to settle the question as to whether real advantage is to be gained by adding germicides to soaps.

The problem is complicated by the difficulty in selecting suitable technics and by the numerous variables. For example, Miller and his colleagues[19] in the course of studies on the effectiveness of cationic soaps as agents for rapid degermination of the hands discovered that these soaps deposit a nonperceptible film on the skin. This film retains bacteria underneath it and is resistant to mechanical trauma. Although the outer surface exerts a strong germicidal action the inner surface of the film has a low bactericidal power. Observations like these complicate not only the evaluation of the particular cationic soaps investigated but suggest that similar problems may exist with other kinds of soaps.

During the war an experimental project was developed with the aim of developing a truly germicidal soap. The compound which so far seems most promising is 2,2′-dihydroxy-3,5,6-3′,5′,6′-hexachloro-diphenyl-methane, which goes under the name of G-11.[20] When 2 per cent G-11 was incorporated in toilet soap it was found possible to maintain an exceedingly low bacterial population on the skin of the hands and forearms. The substance appears to be nonirritating and washing experiments indicate that the regular use of toilet soap containing the compound G-11 has such an effect on the bacterial flora of the human skin that the so-called resident bacteria are decidedly and permanently reduced in number—as long as the use of the soap is continued.

Traub and his colleagues [21] concluded that the daily use of soap containing G-11 would enable a surgeon or operating room attendant to maintain an extremely low resident bacterial population on his skin. This suggests the possibility of shortening the routine operative scrub-up procedures and possibly the elimination of irritating germicides after washing without any sacrifice of skin cleanliness.

The germicidal effect of soaps containing G-11 seems to continue for sometime after actual use. This germicidal substance, therefore, seems to be the most promising preparation so far available for incorporation into soaps used in conjunction with surgery.

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